COMPAGNIE GÉNÉRALE DE GÉOPHYSIQUE

AUSTRALIAN AQUITAINE PETROLEUM PTY. LTD.

KULSHILL SEISMIC & GRAVITY SURVEY

July - October -1964 O.P.2.

COMPAGNIE GÉNÉRALE DE GÉOPHYSIQUE

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K 13	4
K 14	3
K 15	2
K 16	2
K 17	1
K 18	4
K 19	3
K 20	3
K 21	2
K 22	7
K 23	5
K 24	3
K 25	1
K 26	1
K 27	3
K 28	3
K 29	1
K 30	1
K 31	2
K 32	2
K 33	2
TOTAL	60

SUMMARY

A three and a half month seismic and gravity survey was carried out in the Port Keats area of OP 2. lease in Northern Territory, by the :

COMPAGNIE GENERALE DE GEOPHYSIQUE (Australian Branch)

on behalf of :

AUSTRALIAN AQUITAINE PETROLEUM PTY LTD

The production was noticeably improved as compared to the previous 1963 Port Keats Survey .

The reflection work consisted of 23 traverses . They were carried out for detailing the Kulshill structure detected in 1963 and for reconnaissance of the area between this structure and the Moyle River .

Refraction work and offset spreads were conducted the last month of the survey . They suggested that a major north-south fault located about ten miles east of the Kulshill high marks the eastern extension of the basin . East of this fault high-velocity , probably Proterozoic formations rise up steeply .

The Kulshill high is a part of a north-south trend and shows important north, west and probably east closures. Southwards, however, the seismic horizons, as correlated, are in a relatively high position showing a total closure of about 70 milliseconds tone-way time .

The gravity readings completed and extended the map drawn in 1963 without introducing any major alterations to the picture of the area . The gravity map shows particularly well the eastern borders of the basin .

INTRODUCTION

A seismic and gravity survey, subject of the present report, was carried out by :

COMPAGNIE GENERALE DE GEOPHYSIQUE (Australian Branch)

on behalf of :

AUSTRALIAN AQUITAINE PETROLEUM PTY LTD

in the Port Keats area of the Oil Permit OP 2 in Northern Territory , where Australian Aquitaine Petroleum is the operator .

This survey followed the " Pearce Point " seismic, gravity and magnetic survey carried out in 1963, and is called the " KULSHILL " survey.

The Party was capable ,of operating either with the reflection or the refraction method. It included 37 men ,four of them expatriated from France, and 15 basic vehicles .

Two dozers were hired for clearing the seismic traverses and shot-point patterns.

Drilling began on the 11 th July and was completed on the 24 th October 1964 .

Seismic and gravity operations were conducted between the 12 th July and the 26 th October 1964 .

Mr. J.L. PENNACCHIONI, Engineer Geophysicist headed the Party which was supervised by Mr. C. DIKOFF, Engineer Geophysicist .

FIG. 1

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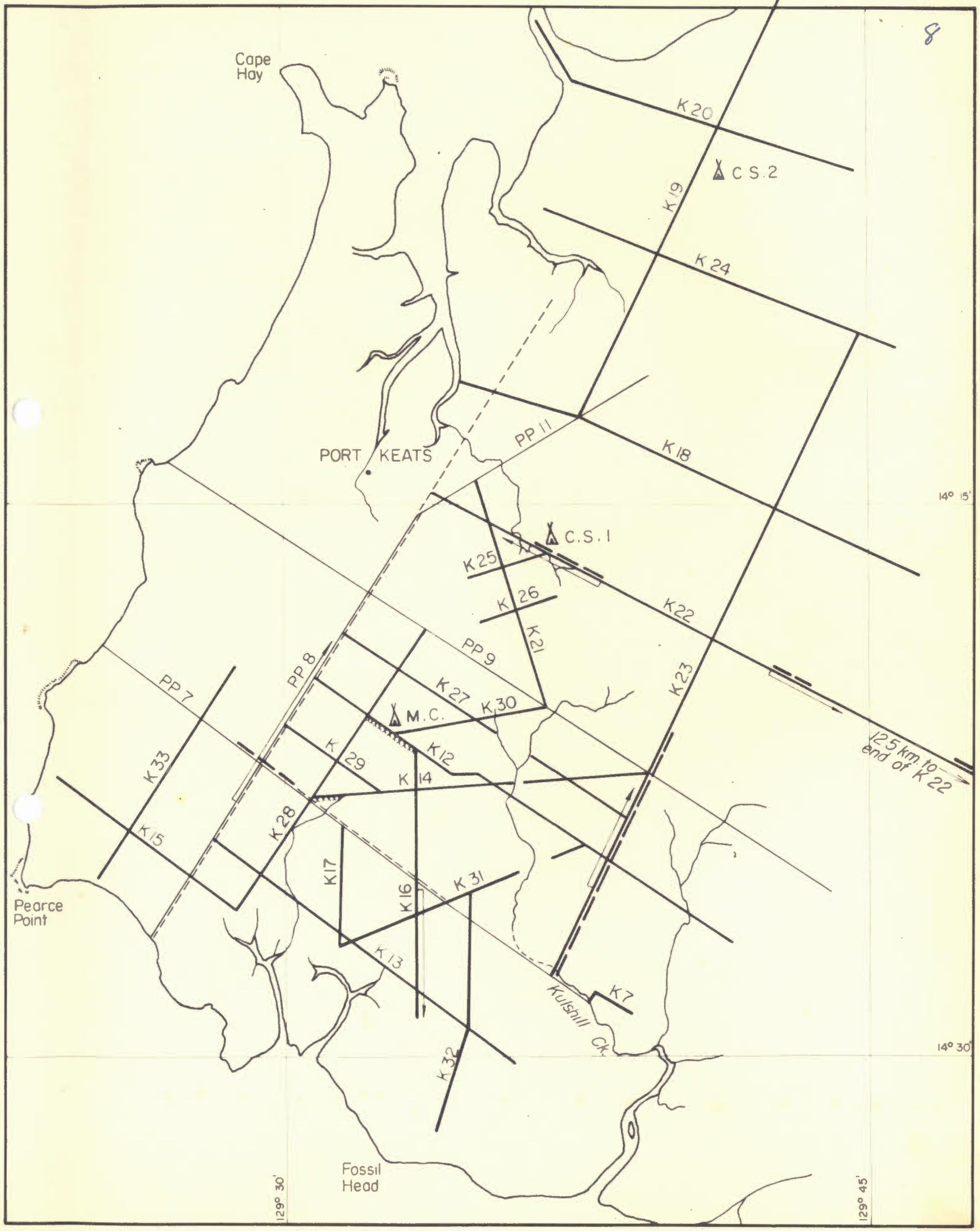
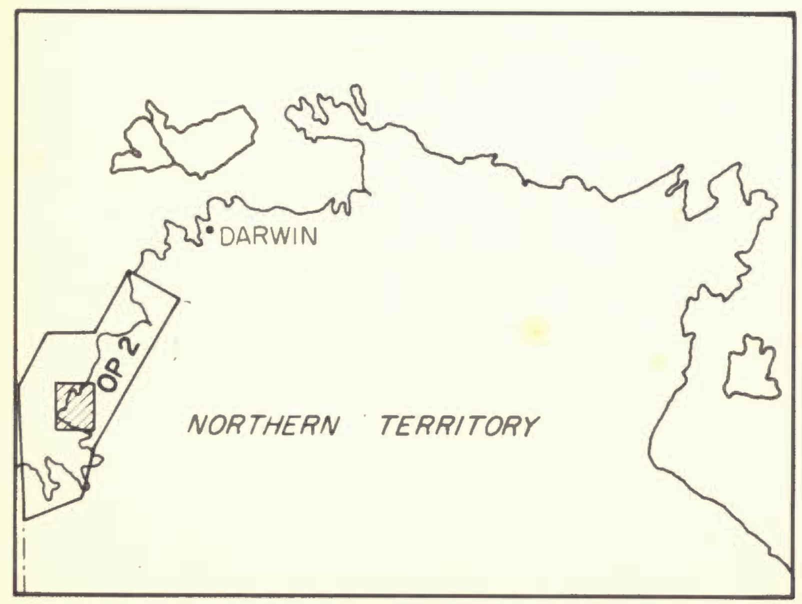


LOCATION MAP

SCALE : 1/250,000

LEGEND

C.G.G. Traverse 1963	Reflection	
	Refraction	
C.G.G. Traverse 1964	Reflection	
	Refraction	
	Offset spreads	
	Experiments	



CHAPTER I

GEOLOGICAL AND GEOPHYSICAL DATA

I- GEOLOGICAL DATA

The available geological data have been summed up in the final report of the " Pearce Point Survey " (August-November 1963). However, we give hereunder again a summary of these data :

This area is mainly covered by the large outcrop areas of Permian and possibly Jurassic age that extend all along the eastern part of the Bonaparte Basin, and which overlap the Proterozoic to the east.

The Permian has a minimum thickness of 1,500 feet, as shown by the old coal bore at Port Keats.

There is a possibility of the existence of a Pre-Permian Basin near Port Keats which could be deep enough to offer good possibilities for oil exploration, and could show a section comparable to that exposed in the southern part of the Bonaparte Basin. In that area, a thick Paleozoic section exists limited to the east by a major fault system (Cockatoo fault system NNE-SSW), and underlying the Permian (Spirit Hill Well No 1 and Bonaparte Well No 1).

The section in the souther part of the Bonaparte Basin is as follows :

AGE	LITHOLOGY	THICKNESS
Permian	sandstones, shales & limestones regional unconformity	1,500 feet
Upper Carboniferous	conglomerates, sandstones) regional unconformity)	
Lower Carboniferous	sandstones, limestones, siltstones) regional unconformity) (intra- visean))	2,700 feet
	shales , limestones, sandstones siltstones	4,500 feet
Upper Devonian	sandstones, limestones unconformity-transgression	6,000 feet
Cambrian -Lower	sandstones & limestones, shales	0'-4/5,000 feet
Ordovician	sandstones unconformity	
Cambrian (?)	basalts, volcanic agglomerates tuffs unconformity	80'-3,000 feet
Upper Proterozoic	sandstones, shales, dolomite unconformity	12,000 feet
Lower Proterozoic	metamorphic complex, granite	Basement

2- GEOPHYSICAL DATA

The previous " Pearce Point" survey revealed the presence of a structure named Kulshill high . It was thought that the structure is extending SSW-NNE parallel to the border of the Basin . So, the general attitude of the sediments, at least the upper ones, appears to be from east to west :

- A syncline area with an eastern flank overlaying the Proterozoic basement .

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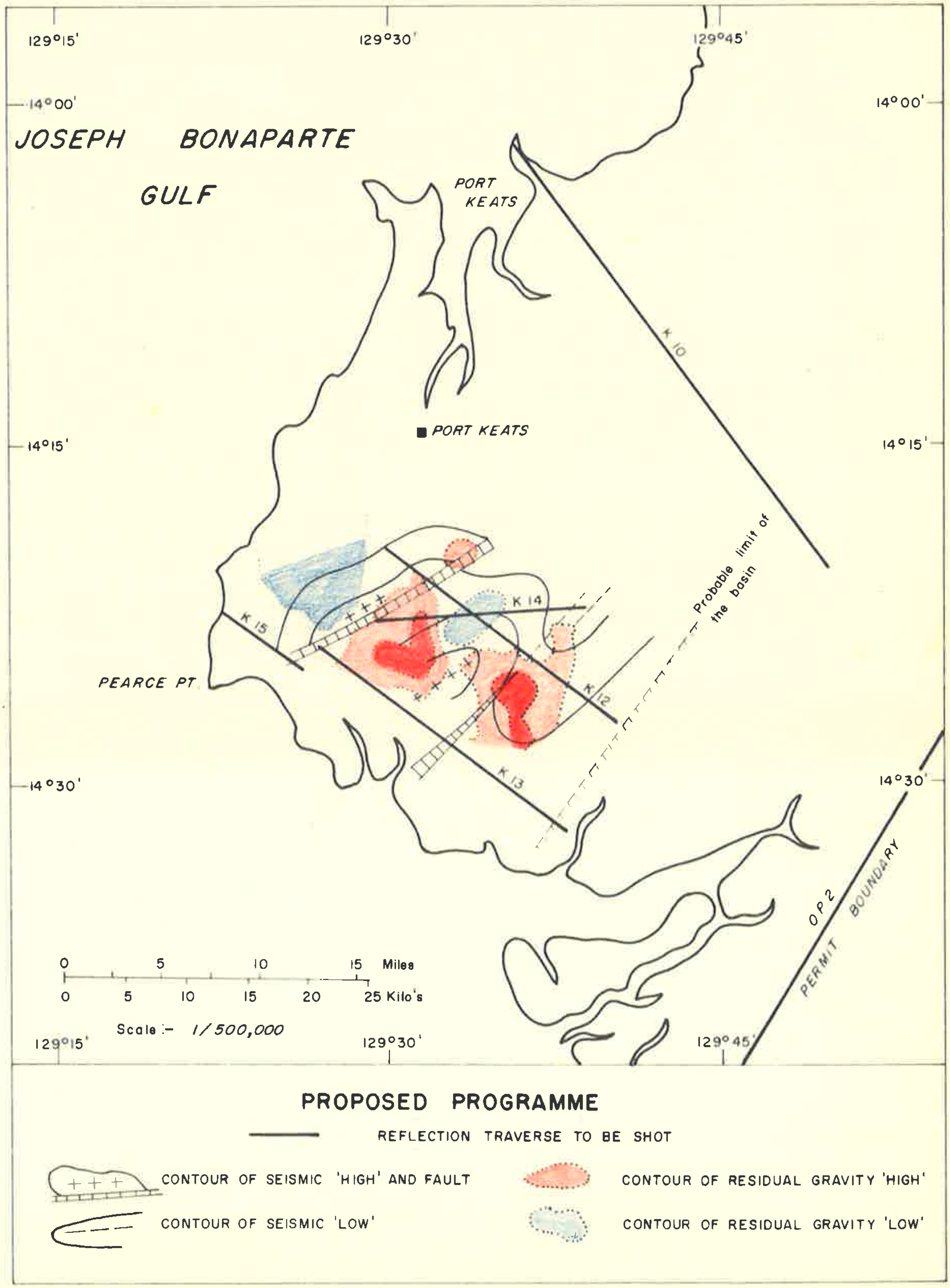
FIG. 2.



129°15'
129°30'
129°45'
14°00'
14°15'
14°30'
JOSEPH BONAPARTE
GULF
PORT KEATS
PORT KEATS
PEARCE PT
K 10
K 12
K 13
K 14
K 15
Probable limit of the basin
OP 2
PERMIT BOUNDARY
0 5 10 15 Miles
0 5 10 15 20 25 Kilo's
Scale :- 1/500,000
PROPOSED PROGRAMME
REFLECTION TRAVERSE TO BE SHOT
CONTOUR OF SEISMIC 'HIGH' AND FAULT
CONTOUR OF SEISMIC 'LOW'
CONTOUR OF RESIDUAL GRAVITY 'HIGH'
CONTOUR OF RESIDUAL GRAVITY 'LOW'

- A structurally high , complex and faulted area of Kulshill ,
- A monoclinical area dipping gently towards the sea .

On the other hand, a residual gravity map showed north-south directions which are probably in relation with deep levels . This direction appears on the isochron map as a protuberance (traverse PP9 of Pearce Point Survey 1963/ of the Kulshill structure .

A study of the geomorphological data seemed to confirm that the fault system on the Kulshill high has a NNW- SSE direction in agreement with the gravity residual map, but different from the direction indicated on the seismic maps (Pl 11 and 12 of the " Pearce Point" survey report) .

These conclusions led to the intended program shown on Fig . 2.

CHAPTER II

OBJECTIVES AND PROGRAMME

1 - OBJECTIVES

1-1 : The aims of the survey were :

- To obtain better definition of the structure revealed during the Pearce Point Survey of 1963, with a view to locating a suitable drilling site .
- To improve the quality of the deeper reflections by experimental shooting, at the same time maintaining an economical and practical spread arrangement .
- To determine the depth to basement, by refraction, below the axis of the anticline. This information would help determine the type of rig needed .
- To follow up the gravity map of Port Keats with gravity readings at each shot point of the present survey .

2 - INITIAL PROGRAMME

The work planned over the area was to make use of seismic reflection, seismic refraction and gravity methods .

The crew was to spend the first six days carrying out experimental shooting to improve the quality of the reflection without using more than 60 geophones per trace .

The initial programme consisted of 5 traverses of continuous profiling covering the Kulshill high and extending over 100 kilometres .

The refraction work would follow consisting of two probes, in order to define the depth to basement. They had to be located after the structures being delineated by the reflection traverses.

A gravity station would be located at each shot-point.

3- MODIFICATION AND SUBSEQUENT PROGRAMMES

3-1: Kulshill area

Following the execution of the initial programme : Traverses K12 to K15, traverses K16 and K 17 were added as well as an eastern extension of PP7 called K7.

3-2: Northern area

A new programme was then defined on the 13 th August, 1964 : for the reconnaissance of the area located between Kulshill and the Moyle River,

- Following a plane reconnaissance, it was decided to work on traverse K 18, K 19, K 20. For K 22, a ground reconnaissance was requested from the crew.
- K 19 would be limited to the north by the Moyle River mark area after approximately 25 km,
- K 18 and K 22 were expected to be extended sufficiently far to the east to reach the margin of the Basin as on PP9, PP7-K7 and K 13. On K 18 this was expected about 25 km east of PP 11 and on K 22 about 28 km east of PP8.

3-3 : Additions in the northern area

Some additional work was decided on the 20 th August 1964 :

- Traverse K 22 was extended to the Proterozoic outcrops, near the permit boundary, over a length of approximately 45 km.
- Traverse K 23 was planned in a north-northeasterly direction, along the quasi-syncline detected east of the Kulshill high, and tying traverse PP7 in the south to traverse K 18. It would extend a few kilometres north of K 18 until the mark is reached.

- Traverse K 24 was planned east-west , across K 19 and mid-way between K 18 and K 20 .

3-4 : Addition in the Kulshill area

An extension of the programme was communicated to the Party on the 9 th September 1964 .

3-4-1- Reasons for the extension :

- The results obtained so far had confirmed and defined the Kulshill structurally high zone but it appeared deeply affected by block faulting which requires a study of the various compartments ,

- Some geological field work conducted in the area suggested the existence of an anomaly between PP 9, PP8 and K 22 .

3-4-2- It appeared necessary, therefore, to conduct the extension in order :

- To complete the reconnaissance of the area between Kulshill and the Moyle River .

- To obtain a definition of the Kulshill area, adequate for locating a suitable drilling site,

- To find out whether or not the geological anomaly exists at depth,

- To determine the depth to basement by refraction under the Kulshill area and in several other places as advisable .

3-4-3- Extended programme:

- The reflection programme consisted of 217 shot points, i.e. 156 km of traverses : K 21, K23 and K25 to K 33 covering mainly the Kulshill structure,

- The refraction programme was to include 36 refraction bases broken down into 3 or 4 depth probes as directed by the results obtained with the reflection method. Longitudinal offset shots were also planned for the correlation of reflection and refraction results.

- In gravity, 3 or 4 density profiles (Nettleton) were requested in places showing sufficient changes in elevation.

4- PROGRAMME TIME TABLE

- The experiments were conducted from the 12 th to the 17 th July 1964.
- Traverse K 12 to K 17 and K 7 were shot between the 18 th of July and the 7 th of August (see programme 3-1- above).
- Traverse K 18 to K 20 and K 22 were carried out between the 9 th of August and the 3 rd of September 1964 (see 3-2 above).
- Traverse K 23 and 24 were shot between the 4 th and the 13 th of September (programme 3-3).
- The last reflection programme (3-4-3 above) took place between the 12 th of September and the 7 th of October,
- From the 8 th of October until the 26 th of October 1964 the Party carried out the refraction probes and longitudinal offset shots.
- From the 12 th July until the 26 th October 1964, the Party carried out:
  - 383 km of new reflection traverses,
  - 36,5 km of new refraction traverses,
  - 65 offset spreads for correlation of reflection and refraction results
  - 677 gravity readings corresponding to 532 new stations, 9 new bases and 3 density profiles

CHAPTER III

TECHNIQUE AND OPERATIONS

I- TECHNIQUE

1-1: REFLECTION

The reflection method used during the survey was the normal split spread method: 24 traces were laid out and the shot was fired mid-way between traces 12 and 13.

Half of the spread i.e 12 traces were then shifted and the next shot was fired in the middle of the new spread. This method provides a full marker coverage.

1-2: REFRACTION

1-2-1 Refraction probe

A probe consists in recording a certain number of consecutive spreads laid out between two fixed shot points. This allows two time distance curves to be plotted, one called " direct" and one " reverse " according to the location of the shot point in regard to the spreads .

An inventory of the markers is made, each marker being characterized by its horizontal velocity. For the present survey, some isolated long distance shots were added in order to check the possible existence of very deep markers .

After trying surface shot on K 22 (eastern part), it was decided to use buried charges which represent about the sixth of the surface charges . This was decided as an economy drive to reduce expenses and difficulties in supplying explosives

1-2-2 Continuous profiling

Some shots were added to the west of line PPR7 in order to extend the interpretation of this line until the crossing with PPR 8 .

The Gardner Layat method of continuous profiling was used (adapted from L.W. Gardner " An Aerial Plan of Mapping Subsurface Structures by Refraction Shooting " geophysics 1947 Vol XII)

1-3 : OFFSET SPREADS

Consecutive reflection spreads were recorded from a given shot point up to a distance where reflected events are replaced by refracted arrivals . This technique aims at a correlation of reflection and refraction events .

2 - OPERATIONS

2-1 : Positioning and withdrawal of the Party

All vehicles reached the Port Keats area by road while the trailers, the power plants, the fuel and explosives came by barge from Darwin . .

The tracks had been improved by a dozer and a grader, but difficulties occured in some swampy areas .

The withdrawal was made in good conditions following a dry spell in weather during the second fortnight of October .

2-2 . Camps

A main camp was located 6 miles south of the Port Keats Catholic Mission .

Two fly camps were settled for the northern part of the survey.

2-3 : Logistics

Water was taken from the Kulshill creek. Travelling distances were of the order of 7 miles .

Perishable foodstuffs were delivered weekly to Port Keats by a chartered plane .

2-4 : Communications

Daily sessions were taken with the Royal Flying Doctor service and with A.A.P ,Brisbane .

2-5 : Bulldozing

Two Caterpillar bulldozers : D 7 and D 8 hired in Darwin cleared the traverses and the shot point patterns. A total of 1,396 dozing hours and 448 moving hours were made .

2-6 : Surveying

Levelling was done with a To Theodolite .

All traverses were tied to the C.G.G. 1963 network . The Universal Transverse Mercator projection system was adopted and all co-ordinates and elevations were calculated in the metric system .

Permanent markers (iron pipes) were placed along the lines approximately every ten reflection shot points.

Location maps were drawn at scales of 1/100,000 and 1/50,000 (Accessibility map).

2-7-: Drilling

Drilling was conducted with two Mayhew 1,000 air/water rotary drills .

5 5/8" and 4 3/4" insert bits were used .

Water drilling was done only in the open plain and in some swampy areas .

Holes were drilled to a depth of 10 ft in reflection and 30 to 60 ft in refraction .

Cuttings were collected at each shot point for the Bureau of Mineral Resources .

2-8 : Shooting

Reflection : The standard shot point consisted of 60 holes in four parallel lines of 15 with 10 metres between holes and 20 metres between lines . The lateral offset of the pattern was 100 metres and the hole depth 10 ft. 2 or 3 lbs of explosives were loaded in each hole immediately after their drilling .

Refraction : One or several holes were drilled at a depth of 30 to 60 feet, depending on the charge to be loaded.

Offset Spreads : A reflection shot point was used for the first offset shot and refraction shot points for the others .

2-9 : Explosives

" NITRAMON " waterproof explosives were used with ICI Submarine detonators .

2-10 : Recording

Reflection :

- Recording on 24 traces, 12 traces between shot points .
- Distance between shot points : 720 metres
- Distance between traces : 60 metres
- 36 geophones per trace, in three parallel lines, 5 metres between geophones and 20 metres between lines .

Refraction :

- Recording on two bases, consisting of 12 traces each .
- Distance between traces 120 metres, except for the KR 22 east (180 metres) .
- 12 geophones per trace in four lines of three, perpendicular to the traverse . Distance between lines and geophones 5 m .

Offset spreads :

- Recording using the reflection spread and geophone patterns

Weathering shots :

Carried out every ten reflection shot points using a special cable with 24 outlets and intervals varying between 5 and 20 metres .

The recording unit was a " C.G.G. 59 " pulse-width modulated magnetic assembly . It was equipped with a silmutaneous SIE-PRO 11 photographic recording oscillograph and a sequential play-back Electrotech M.T.D.

The magnetic tapes were processed directly in the filed and corrected for both static and move-out corrections, trace by trace .

2-11: Gravity

The gravity stations corresponded to the reflections shot points, therefore the spacing was 720 metres . All new reflection shot points were read and the network of new bases was tied to the " Pearce Point 1963" network . The operator's programme were prepared in order not to exceed a duration of four hours .

Remark : Operations are discussed at length in Appendix IV of the present report .

CHAPTER IV

RESULTS

I- REFLECTION

The reflection work consisted of 23 traverses. They were carried out for detailing the Kulshill structure detected in 1963 and for reconnaissance of the area between this structure and the Moyle River .

The best records were obtained in flat areas in the Southern part of the survey : traverse K 13, K 32 (south) K 15 and K 33 .

Some areas gave poor results, like traverse K 14 and part of traverse K 12, because of unfavourable and combined topographic irregularity and tectonic complexity .

The main continuous horizons were plotted on time cross-sections at a scale of 1/ 50,000 (Pl 19). Indications concerning the limit of continuous events and other characteristics features ; the information supplied by the offset spreads and the refraction shooting were also added on the plates .

A contour map of the most continuous and reliable horizon was drawn at a scale of 1/100,000. This horizon corresponds to "Horizon2" of the " Pearce Point Survey " traverse PP7-PP8-PP9 and PP11 .

However, the relatively dense network of seismic traverses revealed the presence of major faults which divide the surveyed area into distinctive compartment, the mapped horizon corresponds to a different geological formation .

It appears that the major faults, F 1, F 2 and F 3 divide the surveyed area into four compartments, the correlation being easier across the fault F 4.

The major feature of the presented map is the Kulshill High. It is a culmination located on a north-south high trend, underlined by two small "highs" situated north of traverse PP9 and south of K 13.

This trend is bordered to the east by a syncline deepening northwards. Two faults F3 and F4, the most important being to the east, offset the eastern and western flanks of the Kulshill structure.

To the west, the regional dip is interrupted by a structural high (traverses K 15-PP8). Its extension is probably restricted.

The northern part of the survey shows a regular and gentle dip towards the Bonaparte Gulf.

II- REFRACTION

Refraction work and offset spreads were conducted the last month of the survey. They suggested that a major north-south fault located about ten miles east of the Kulshill high mark the eastern extension of the basin. East of this fault high-velocity, probably Proterozoic formations rise up steeply.

The purpose of the refraction work carried out during the present survey was to check the previous results and to bring about some elements which would facilitate the correlation of reflection horizons cut up by a complex fault system.

However, the locations for a possible refraction work (refraction probe or continuous profiling) are very restricted because of major faults or topographic difficulties. Three short and imcomplete refraction probes were carried out along traverse K 22, a refraction probe was shot in the southern part of traverse K 23, a refraction traverse PPR 7 was extended westwards until the crossing with traverse PPR 8.

III- GRAVITY

The gravity readings completed and extended the map drawn in 1963 without introducing any major alterations to the picture of the area . The gravity map shows particularly well the eastern borders of the basin.

All the stations were located at the seismic shot-points and the duration of the programme , i.e readings at a base, at stations and at next base was always inferioir to 4 hours in order to control the drift of the apparatus .

For the same reasons, readings at certain stations were repeated in order to control the quality of the readings and the evolution of the gravity meter .

A tidal correction and a gravitymeter drift correction were applied, the drift being considered a linear function of the time .

The values found for the Bouguer anomaly are plotted on the Bouguer anomaly map .

3-1- Accuracy

All bases connections were made according to the usual requirements : less than 0.1 milligal discrepancy .

The repartition of discrepancies observed at the 47 repeated stations (9% of the total new stations). leads to a mean probable error of 0.01 to 0.03 milligal .

The Kulshill High is a part of a north-south trend and shows important north, west and probably east closures. Southwards , however, the seismic horizons, as correlated, are in a relatively high position showing a total closure of about 70 milliseconds tone-way time.

CHAPTER V

DISCUSSION OF RESULTS AND INTERPRETATION

PART ONE : REFLECTION RESULTS

I- EXPERIMENTS

The objectives of the experiments conducted during the first week of the survey,the field operations,the parameters studied and the conclusions drawn are explained in Appendix IV . Play-Backs of the experiments are presented on plates 23 and 24 .

We will briefly recall the conclusions :

- 72 geophones per trace give only slightly improved records compared with 36 geophones per trace covering the same surface , but it is a very heavy spread to lay down along the traverse in this timber-covered area .
- Surface covered by the geophones pattern is an important factor .
- The best improvement of the records quality is obtained when the shot point is offseted perpendicularly to the traverse .The optimum offset is considered to be around 130 metres .

2- QUALITY OF THE REFLECTION RESULTS

The quality of the reflection records has already been discussed in the previous " Pearce Point Survey " report (Chapter V-2). But as a result of the new experiments,the quality remained good although using a spread not as heavy as the one used the previous year .

The best records were obtained in flat areas in the southern part of the survey : traverse K 13,K 32 (south),K 15 and K 33 .

Some areas gave very poor results, like traverse K 14 and part of traverse K 12, because of unfavourable and combined topographic irregularity and tectonic complexity .

3- DOCUMENTS PRESENTED

The sixty variable area reflection cross-sections were too bulky to be included in the report .

The main continuous horizons were plotted on time cross-sections at a scale of 1/50,000 (Pl19) . Indications concerning the limit of continuous events and other characteristics features, the information supplied by the offset spreads and the refraction shooting were also added on these plates .

The most continuous and characteristic horizon mapped at a scale of 1/100,000 (Pl 20) .

4- EXAMINATION OF THE CROSS-SECTIONS

Certain common features allow to classify the different traverses into groups :

4-1 : Traverse north of traverse PP9 (K21-25-26-22-18-19-20-24-&K23 north)

This group can be subdivided in two groups according to the location in respect with the major F1 (see " Contour Map " Pl 20)

- West of F 1 : two strong and continuous horizons are pickable at about 600 msec one way-time .

They are separated by 70 to 100 msec one way-time. No shallower horizons are continuously pickable. Below the main reflectors conformable and semi-continuous horizons are pickable down to 1,200- 1,300 msec except on traverse K 18 where reflections are visible down to 1,700 msec.

Remark : All reflection times are one-way vertical times .

- Near fault F1 east of F 1 there is only one continuous reflector .

4-2 : Open plain and flat areas (K13-15-32-33)

This group is characterized by a strong reflector pickable between 300 and 600 msec and multiple reflections invading the entire records . Shallow reflectors are visible but they are not quite continuous .

4-3 : Southeastern zone of the survey (K 23 south K12 east)

Two main horizons can be followed at 400 and 600 msec. The interval reduces when the horizon rises . Semi-continuous reflectors are visible below the main horizon but none of them is reliable and there is no indication concerning the depth of the basin .

4-4 : Central zone of the survey (all other traverses)

Only one horizon is followed in continuity. In nearby horizontal areas deeper, semi-continuous horizons, are pickable . They would be conformable with the main horizon .

In dipping zones , line-ups showing a dip increasing with the depth are visible .

5- CONTOUR MAP OF HORIZON 2 (1963) (Pl 20)

A contour map of the most continuous and reliable horizon was drawn at a scale of 1/100,000 . This horizon corresponds to " Horizon 2 " of the " Pearce Point Survey " traverses PP7-PP8-PP9 and PP11.

However, the relatively dense network of seismic traverses revealed the presence of major faults which divide the surveyed area into distinctive compartments. It is most probable that in each compartment, the mapped horizon corresponds to a different geological formation (see Part four -3).

5-1 : Source of information

All time-cross sections established during the present survey .

All traverses of the 1963 " Pearce Point Survey ". Variable area cross-sections of the reliable part of lines 1 to 6 (" Port Keats Survey 1961 ") were supplied by A.A.P.

5-2 : Correlation of faults

5-2-1 : A major fault F1 was intersected by all seismic traverses north of K 22 . Its north-south direction and its west down throw are certain .

South of the traverse K 22 , F1 affects the traverse K 23 (SP's 564 to 572) but it seems that there is a slight change of direction since on traverse PP9 the fault area occurs at the eastern end of the line .

5-2-2 : A second major faulting system F 2 crosses the surveyed area along a northeast-southwest direction. This fault, seen on traverse K 15-PP 8-PP7 (refraction)-K28-K29 -K16 and possibly K 12 and K 23, would explain the very poor results obtained along most of the traverse K14 .

Its north downthrow decreases eastwards.

5-2-3 : A north-south fault F3, parallel to F 1 is suggested by faulted zones crossed on traverses PP7 - K13 and traverse 1. It would be downthrown to the east and does not extend north of F2 .

5-2-4 : A minor fault F 4, was found , parallel to F 3 and five miles to the west : nil result zones were crossed on traverses PP7-K31 and K13 . The downthrow is to the east and appears to increase southwards from PP 7 to traverse K 13.

In short, it appears that the major faults, F1, F2 and F 3 divide the surveyed area into four compartments, the correlation being easier across the fault F 4.

5-3 : Description of the map (Pl 20)

The major feature of the presented map is the Kulshill high . It is a culmination located on a north-south high trend, underlined by two small " highs" situated north of traverse PP 9 and south of K 13.

This trend is bordered to the east by a syncline deepening northwards. Two faults F3 and F4, the most important being to the east, offset the eastern and western flanks of the Kulshill structure .

To the west, the regional dip is interrupted by a structural high (traverses K 15-PP8) . Its extension is probably restricted .

The northern part of the survey shows a regular and gentle dip towards the Bonaparte Gulf.

5-3-1 The Kulshill high was well delineated during the present survey. It appears as a structure closed in all directions , cut by three major faults F2, F3 and F4. It culminates at about 250 msec south of fault F 2 . Steep dips characterized its northern and western flanks while fault F 3 should secure the eastern closure .

This closure is however of the order of only 70 msec because of the high attitude of the horizons along the axis of the trend (minor culmination visible along traverse K 32 south)

5-3-2 : The alleged syncline, east of the Kulshill high, in 1963, was confirmed by traverses K 23, K 12 and K 22 .

Its direction is not well defined . This low zone suggests the existence of a deep basin off the coast (continuous reflections pickable down to 1,700 msec on traverse K 18 west).

5-3-3 : The fault F2 splits a minor structure presenting a limited interest near the crossing of traverse PP 8 and K 15 . The culmination, at 400 msec is south of F 2.

-5-3-4 : The fault F1 probably underlines the eastern limit of the sedimentary basin (see Prt three-3) .

PART TWO : REFRACTION RESULTS

In 1963, during the " Pearce Point Survey ", reflection and refraction work were conducted along two traverses : PP7 and PP 8. It was found that the main refractors : V = 4,980 m/sec on line PP 8 and V = 4,550 m/sec on line PP7 underly the main reflector, followed along this traverses by 100 to 150 msec one-way time .

The purpose of the refraction work carried out during the present survey was to check these results and to bring about some elements which would facilitate the correlation of reflection horizons cut up by a complex fault system .

However, the locations for a possible refraction work (réfraction probe or continuous profiling) are very restricted because of major faults or topographic difficulties . Three short and incomplete refraction probes were carried out along traverse K 22 , a refraction probe was shot in the southern part of traverse K 23 and the refraction traverse PPR 7 was extended westwards until the crossing with traverse PPR 8 .

1- REFRACTION WORK ALONG TRAVERSE K 22

1-1 : Documents presented in this report and concerning the refraction work along traverse K 22 include :

- an " Operational diagram " (Pl 5) giving the particulars of the recording operations .
- " Time-distance curves " (Pl 6 to 8) with a plotting of all refracted events .
- an " Interpretation diagram "(Pl 9) showing an analysis of the records and a synthesis of the results .

1-2: Quality of the results

Results are complex to the east with records showing important energy changes and interferences . They are fair in the middle part of the line and good in the west .

1-3: K 22 -east (Pl 6 and 9)

Shots were performed over 4 bases , i.e. 8.5 km , at distances ranging from 0 to 20 km .

Low velocity arrivals : 2,250 to 2,500 m/sec were recorded only from) to 1 km shooting distance . Beyond, horizontal velocities of 5,000 to 6,000 m/sec were recorded . Correlation of these arrivals is difficult because of the interference and a probable minor fault at the end of base 302. Events recorded beyond the faulted zone (base 303 shot from the east) are hardly pickable .

Two markers were probably recorded :

- A shallow one , with a horizontal velocity of the order of 5,100 m/sec .
- A slightly deeper one, the velocity of which is unknown because of the delicate correlation of events recorded from shot points 17 km apart (SP's 487 and 511) .

This could be the basement according to the results obtained from SP 487 and 477 : similar apparent velocity and good conservation of the energy ..

1-3 : K 22 - centre (Pl 7-9)

Only two bases were recorded with shooting distances of 5 to 20 km . For an easier correlation from trace to trace , the distance between traces was reduced from 180 to 120 metres . For a more complete information , results of the offset spreads shot from SP 478 were also plotted on Pl 7 and 9 .

Low velocity arrivals : 2,830 m/sec were recorded from 0 to 2 km.

As for the previous probe, high apparent velocities were then recorded : 6,000 to 6,850 m/sec .

The 6,000 -6,140 m/sec apparent velocities recorded between 5 and 8 km shooting distance indicate the presence of a 6,100 m/sec (approximate value) marker underlaying directly the low velocity formations .

The very different values (6,650-6,850 m/sec) found for the shot recorded from 17.5 to 20.5 km suggest a change of marker although the recordings have a similar appearance : low energy level, double on signal .

<u>1-5 : K22 west (P 18 and 9)</u>

Four bases ,i,e, 6 km with a trace spacing of 120 metres were shot from both sides ,the shooting distances ranging from 2 to 12.6 km .

A series of arrivals were recorded, separated by breaks easy to locate .

A correlation of direct and reverse arrivals was attempted and the interpretation is schematically represented on plate 8. The following markers would be present in the area :

- a 3,000 m/sec shallow marker, recorded from 2 to 4 km .
- a 3,350 m/sec marker, recorded from 3.5 to 5 km .
- a 3,600 m/sec marker, recorded for distances of 5 to 9 km .
- a 4,875 m/sec marker (apparent velocity) recorded beyond 9 km .

All velocity values are approximate, being the average value of correlated direct and reverse apparent velocities .

1-6: Synthesis - General remarks

A synthesis of the results is presented on the upper part of Pl 9.

The important fault seen in reflection between SP's 472 and 475 separates two different compartments .

To the west, results are comparable to those obtained along traverse PPR 8 in 1963 :

- presence of three, probably thin , sedimentary markers with velocities of 2,800-3,000 , 3,350-3,500 and 3,600-3,750 m/sec ,
- underneath, a thick formation gives rise to strong arrivals recorded 10 to about 20 km . Its velocity determined by the Gardner-Layat method of continuous profiling is about 5,000 m/sec.

East of the fault, all these sediments have not been deposited or have been eroded . The high velocity arrivals : 5,000 to 6,000 m/sec underlying undifferentiated sediments could originate from Proterozoic formations. In any case, these formations are heterogeneous as shown by the range of the apparent velocities recorded .

There is a regular west dip . The high velocity formations rise up towards the south-eastern end of the traverse until their plotting becomes possible on the first breaks of the reflection records (SP's 507 to 513) .

2- REFRACTION PROBE KR 23

2-1 : Field operations

Ten bases were laid down south of the major fault seen in reflection at the crossing of traverses K 22 - K 23. The distance between traces was 120 metres . The total length of the probe was 14.4 km and, in order to record up to a distance of about 20 km, an additional shot point was located 6.3 km south of the probe, in the open plain .

2-2 : Documents presented

- Pl 4 photoreduction of the time-distance curve recorded from SP 595.
- Pl 10 : " Operational diagram ", showing the particulars of the recording operations .
- Pl 11 : " Time-distance curves " with a plotting of all picked arrivals .

2-3 : Quality of the results

Results were of a good quality as shown by Pl 4. However, in order to have records of a comparable quality, very heavy charges were to be used at SP 575 . The statistical study of the charges (Pl 10) proves that a ratio superior to 7/1 existed between the charges used at the northern and the southern shot points, although the reflection results do not indicate any particular reason .

2-4 : Results (Pl 11)

The following arrivals were recorded :

Distance in Km	Apparent velocity in m/sec
0 - 1.4	2,500 - 2,520
0.7 - 5.16	2,980 - 3,120
4.08 - 6.72	3,640 to4,180
6.36 - 12.72	4,550 - 4,650
12.24 - 20.	5,300 - 5,650

Breaks are easy to locate and several markers were picked as second arrivals before their appearance as first arrivals (see Pl 4).

For the arrivals recorded up to 6-7 km the energy decreases rapidly when the shooting distance increases. The energy level remains relatively constant for all arrivals recorded beyond 7 km .

2-5 : Interpretation

A correlation of " Direct" and " Reverse" arrivals was attempted, schematically represented on Pl 11. The following markers could have been recorded :

- a 2,500 m/sec marker , base of the weathered zone ,
- a 3,000 m/sec refractor , from 0.7 to 5 km ,
- a possible 4,000 m/sec marker, recorded from 4 to 7 km. These could be a 3,600 m/sec sequence to the south, disappearing northwards.
- a 4,600 m/sec marker, pickable between 6 and 13 km ,
- a 5,450 m/sec horizon, recorded beyond 12 km.

The correlation of the two long distance shots with the refraction probe shots presents some difficulty because of the presence of three different arrivals with 5,000-5,300 and 5,650 m/sec velocities .

The 5,650 m/sec first arrivals should correlate with the 5,300 m/sec arrival recorded from SP 595 beyond 12 km . The increased apparent velocity could be explained by a deepening of the refracted waves when the shooting distance increases, allowing them to reach deeper and faster formations .

The 5,000 m/sec would be an interference or a late arrival of the 4,550 m/sec marker .

Some additional shots would have helped to explain the origin of the late and very strong arrival 5,300 m/sec, rigorously parallel to the arrival recorded from SP 595 .

The comparison of intercepts calculated at SP's 595 and 575 suggests a slight northward dip for the deeper markers : 4,600 and 5,450 m/sec .

3- REFRACTION TRAVERSE PPR 7

3-1 : Field operations

Three bases were added to the 1963 refraction traverse PPR 7 in order to secure a crossing with the 1963 refraction traverse PPR 8 .

The shooting distances and the charges were determined according to the 1963 values .

3-2 : Documents presented

Pl 12 : " Interpretation diagram " : it is the diagram of the " Pearce Point 1963 " survey (Pl 17) to which the results obtained during the present survey were added .

Pl 13 : " Interpretation plate ": summarizes the Gardner-Layat method of continuous profiling applied to this traverse .

3-3 : Results (Pl 12)

Spreads recorded from the west were of good quality , showing a strong and pure signal .

As expected, a break at a distance of about 8 km, separates the arrivals followed in 1963 from lower velocity events (3,000-3,200 m/sec).

Spreads recorded from the east showed complex and interfered arrivals on base 208, suggesting the presence of a fault .

Apparent velocities of 4,500 to 5,025 m/sec were recorded on the last two bases shot at distances of 7 to 20 km .

3-4 : Interpretation (Pl 12-13)

The important change of apparent velocity : 4,500 to 4,900 m/sec noticed on the two first recordings on bases 209-210, shot from the east, is compatible with the alleged change of marker at 9 km, on bases 204 to 207 .

Therefore, the interpretation of 4,550 m/sec marker followed in 1963 was continued westwards using shot recorded between 6 and 9 km for this shooting direction .

All intercepts were re-computed with a velocity of 4,300 m/sec closer to the marker actual velocity . Results of the Gardner-Layat interpretation are presented on Pl 13 .

The following changes have been made in comparison with Pl 18 of the " Pearce Point Survey " report :

- an actual velocity of 4,500 m/sec was computed for bases 200 to 207 .
- in was not taken into account of the doubtful fault visible on bases 202-203.

The possible fault noticed on base 208 (3-3 above) corresponds to a velocity change : 4,500 to 4,700 m/sec from east to west .

3-5 : Traverse PPR 7 -PPR 8 crossing (Pl 13-)

At the crossing point of traverses PPR 7 and PPR 8 the marker velocity and the delay are as follows :

PPR 7	:	4,700 m/sec , 462 msec ,
PPR 8	:	4,980 m/sec , 475 msec .

The discrepancy , in our opinion, is due to the different shooting distances used for the interpretation : along traverse PPR8 intercepts were computed for shooting distances exceeding 10 km whilst, along traverse PPR 7, intercepts corresponding to shooting distances of 6 to 10 km were selected .

The velocity discrepancy could also be exaggerated by an anisotropic effect, PPR 8 and PPR 7 being perpendicular .

PART THREE

1- OFFSET SPREADS

1-1. Programme

Offset spreads extending over distances of 5 to 10 km were decided at various locations where they could help the correlation of reflection and refraction arrivals.

Three locations were chosen close to a refraction probe : K 22 SP's 465 and 478, K 23 SP 583. One took place on traverse K 16 but close to the crossing with the refraction traverse PPR7 and the last one was carried out on traverse PP8.

1-2. Documents presented

Pl 14 to 17 present an assembly of corrected play-backs with a picking of the different reflections and refracted arrivals.

1-3. Results and Interpretation

1-3-1. K 22 SP 465 (Pl 14 a)

This SP has been used for a refraction probe (see Pl 9). Beyond the 2,550 m/sec shallow arrival, the same succession of arrivals was found: 2,800 - 3,300 and 3,600 m/sec. The distance of 7.92 km was obviously too short to allow a correlation of the " 4,875 m/sec" marker, recorded in refraction at 9 km with the corresponding reflection horizon.

However, a probable correlation was assumed and indicated on Pl 14 a, locating the reflector 130 msec one-way time deeper than the mapped horizon.

1-3-2. K 22 SP 478 (Pl 14 b)

A reliable correlation of the mapped horizon with the high velocity arrivals recorded as from 2 km is provided by these offset spreads.

1-3-3. K 23 SP 588 (Pl 15)

The refracted arrivals can be compared with those recorded from SP 595 of the refraction probe KR 23 :

SP 595	SP 588
2,500 m/sec	2,800 m/sec
2,980	3,000
3,640	3,900
4,180 - 4,550	4,300

The 3,900 m/sec arrival could correlate with a reflection pickable at 270 msec one-way time and the mapped horizon with the 4,300 m/sec refracted arrivals .

1-3-4. K 16 SP 325 (Pl 16)

Low velocity refracted arrivals are recorded up to a distance of 5 km : 2,500 - 2,700 and 2,800 m/sec . They would correspond to shallow reflections, down to 200 msec one-way time .

Beyond 5 km strong 4,ooo m/sec arrivals are easily pickable . They correspond, most probably, to a reflection timed at 410 msec one-way time , i,e 70 msec one-way time below the mapped horizon .

1-3-5. PP 8 SP 110 (Pl 17)

Along the 1963 reflection-refraction traverse PP 8 offset spreads were recorded up to a distance of 9.6 km, the shot point used being located 2.4 km north of SP 9917 which was the southern S.P. of the 1963 refraction probe (see Pl 13 of the 1963 " Pearce Point Survey" report)..

The refraction velocity values are comparable and the 4,550 m/sec arrival recorded beyond 7.5 km corresponds to the 4,980 m/sec marker studied by the Gardner-Layat method in 1963 .

Correlation of reflection and refraction arrivals is hazardous because of the very low level of reflected energy pickable on the records .

It is assumed that the 4,550 m/sec arrival corresponds to a reflection timed at 580 msec one - way time, about 120 msec deeper than the mapped horizon .

2- REFLECTION-REFRACTION COMPARISON

2-1. Traverse PP7

A valuable information for the comparison of reflection and refraction results is supplied by the offset spreads carried out on traverse K 16. The shot point used : SP 325 is at the crossing of this traverse with PP 7 : SP 17 .

Results obtained on both traverses are quite comparable : the 4,000 m/sec arrivals of Pl 16 correspond to the 4,150 m/sec arrivals recorded beyond 5-6 km on bases 200-201 of the traverse PP R 7 (Pl 12). Hence, it can be assumed that the vertical one-way time of 410 msec read on Pl 16 (see 1-3-4 above) corresponds to the delay time of 312 msec read at SP 17 of traverse PPR 7 (Pl 13), the marker velocity being 4,500 m/sec.

$$\text{Therefore } \cos a = \frac{\text{Delay Time}}{\text{Vertical time}} = \frac{312}{410} = 0.76$$

This value was used for the delay times to vertical times conversion along traverse PP7 (see the PP7 cross-section) .

$$\text{Since } \cos a \doteq 0.76 \text{ , } \sin a = 0.65 = \frac{\text{vertical velocity}}{\text{marker velocity}}$$

and the vertical velocity Vo = 0.65 x 4,500 = 2,900 m/sec. This is a confirmation of the value adopted for the delay to depth transformation in 1963 .

FIG. 3. STATISTICS **KULSHILL SEISMIC SURVEY 1964** 52

SEISMIC

REFLECTION

MONTHS	LINES	Recording Time: PRODUCTION	Recording Time: TRAVELLING	Recording Time: TOTAL	Production: NEW SPREADS	Production: REPLACED	Production: SPECIAL SPREADS	Production: TOTAL	Production: W. Z.	Production: NEW KILOM. OF LINE	Ratios: SPREAD PER PROD. HOUR	Ratios: KILOM. PER PROD. HOUR
JULY 12 - 31	K 12-13-14-15	182	21 3/4	203 3/4	98		10	108	11	71	0·59	0·38
AUGUST 1-31	K 7-12-16-17 -18-19-20-22	230 3/4	42 1/2	273 1/4	188			188	19	135	0·82	0·59
SEPT. 1 - 30	K 15 21 to 31	262 1/2	47 1/2	310	209			209	20	150·5	0·80	0·57
OCT. 1 - 26	K 31-32-33 PPR 8	124 1/2	26	150 1/2	36		55 ⊗	91		26·5	0·73	0·11
	KR 22 KR 23 PPR 7											
Total Days 107		799 3/4	137 3/4	937 1/2	531		65	596	50	383	0·75	0·48

REFRACTION

MONTHS	LINES	Recording Time: WORKING DAYS	Recording Time: PRODUCTION	Recording Time: TRAVELLING	Recording Time: TOTAL	Spreads: NEW	Spreads: RESHOT	Spreads: PROBE	Spreads: TOTAL	Bases: NEW	Bases: REPLACED	Bases: PROBE	Bases: TOTAL	Lines: KILOMETRES	RATIOS: BASES PER WORKING Hr.	RATIOS: SPREADS PER WORKING Hr.
	KR 22 KR 23 PPR 7	10	101 3/4	32 1/4	134	32	16	17	65	14		10	24	36·5	0·25	0·65
Total Days 107		10	101 3/4	32 1/4	134	32	16	17	65	14		10	24	36·5	0·25	0·65

REMARKS

GRAVITY

First reading: 26 th. August.

Last reading: 11 th. October.

New station: 532

Repeated station: 47

Density profiles: 3

Total readings: 677

⊗ 55 Offset spreads corresponding to 33 replaced kilometres

DRILLING

MONTHS	Drilling Time: PRODUCTION TIME	Drilling Time: TRAVELLING	Drilling Time: TOTAL	Production: SHOT POINTS	Production: HOLES	Production: FOOTAGE	Ratios: FOOTAGE PER PROD. HOUR	Ratios: FOOTAGE PER TOTAL HOUR
JULY 11 - 31	346 1/2			123	7,378	73,910	214	
AUGUST 1-31	484 1/4			192	11,520	115,200	238	
SEPT. 1 - 30	534			204	12,240	122,400	229	
OCT. 1 - 24	245 1/4			64	1,915	27,740	113	
Total Days 106	1610			583	33,053	339,250	211	

DOZING

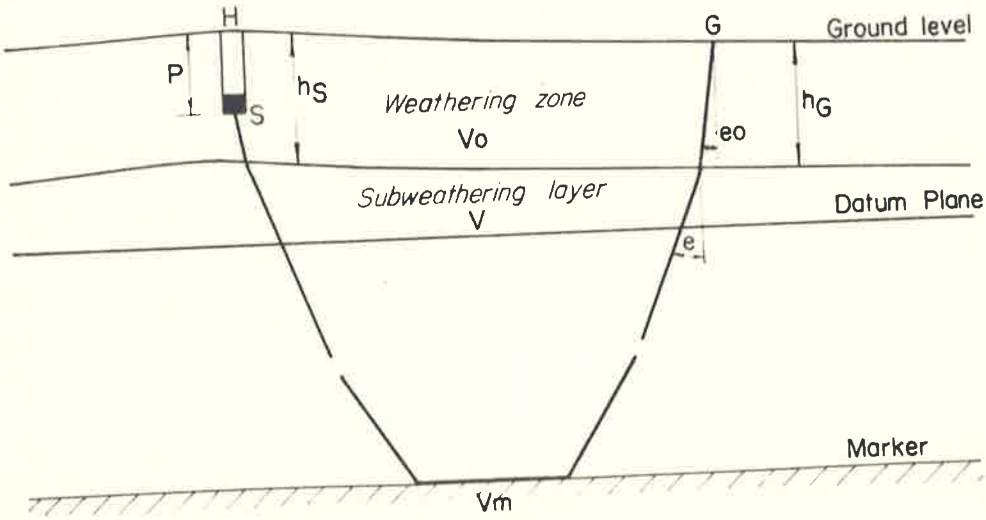
MONTHS	2 CATERPILLAR D7-D8: Dozing Hours	Moving Hours	Km./Dozing Hour	Km./Moving Hour
JULY	298	173	0·44	285
AUGUST	475 1/2	144 1/2	0·58	3·0
SEPT.	517 1/2	92 1/2	0·60	2·7
OCT.	105	38	0·49	2·6
	1,396	448	0·55	2·8

CONSUMABLE STORES

Drilling Stores: INSERT BITS 5 5/8"	INSERT BITS 4 3/4"	INSERT BITS ROCK 4 3/4"	INSERT BLADES			GAS PIPE 2"	Explosives (lbs): NITRAMON	Explosives (lbs): PRIMER	Deton^r.: 30'	
12		1					14,966	7,489	7,670	
21	9	6					15,932	11,698	11,180	
15	7	3					12,718	12,274	12,450	
1	12	1					10,488	9,467	2,292	
49	28	11				500 ft	54,100	40,928	33,592	

FIG. 7.

REFRACTION CORRECTIONS



Vo = Weathering zone velocity

V = Elevation correction velocity

Vm = Marker velocity

$\text{Sin } e = \frac{V}{Vm}$ $\quad \text{Sin } eo = \frac{Vo}{Vm}$

D.P. = Elevation Datum Plane

SHOT POINT CORRECTION

Z S.P. = S. P. Elevation

P = Maximum depth of the hole

h_S = Depth of the weathering zone beneath the S.P.

C_{SP} = S.P. elevation correction = $\frac{D.P.-(Z_{SP}-P)}{V/\cos e}$

CH = Horizontal correction if any

C_{WZ} = Weathering correction to the S.P. = $(h_S - P)\left(\frac{1}{V/\cos e} - \frac{1}{Vo/\cos eo}\right)$

$\Sigma c = C_{SP} + C_{WZ} + CT + CH$

GEOPHONE CORRECTION

Z_G = Geophone elevatton

h_G = Depth of the weathering zone beneath the geophone

E_C = Elevation correction = $\frac{D.P - Z_G}{V/\cos e}$

C_{WZ} = Weathering zone correction to the geophone = $h_G\left(\frac{1}{V/\cos e} - \frac{1}{Vo/\cos eo}\right)$

STATIC CORRECTION

$\Sigma C = \Sigma c + C_{WZ} + Ec$

The time cross-section of traverse PP7 shows a good conformity of the reflection and refraction horizons.

The later lies 100 to 130 msec deeper except for the culmination : SP's 20 to 22 but there the reflection results are not very reliable .

2-2 . Traverse K 22

Another value for cos a , but questionable because the delay-time is unknown, is supplied by the offset spreads recorded from SP 478 (Pl 146). To a vertical two-way time of 448 msec corresponds an intercept of 370 msec (Pl 7): thus cos a is approximately $\frac{370}{448} = 0.825$.

This value was adopted for an intercept-time to vertical-time transformation of the intercepts calculated along traverse K 22 and plotted on Pl 9 .

This allowed to extend the reflection horizon eastwards, in an area where the reflection results show a lack of continuity .

3- TENTATIVE IDENTIFICATION OF THE MAPPED HORIZONS

3-1 . A tentative identification was proposed in the 1963 report, it was assumed (P. 42) that the reflection horizon 2 might be Carboniferous and the refraction marker 4,550-4,980 m/sec related to Devonian formations as it is considered that, in the stratigraphic scale, only the Devonian limestone may give velocities up to 5,000 m/sec .

On the other hand A.A.P. has conducted a seismic survey in the LEGUNE area where slow velocities (4,500 m/sec) were recorded on upper Proterozoic outcrops .

Untill the data from the well to be drilled on this area are known, it seems more advisable to speak only of seismic horizons and correlation between seismic horizons than to give geological names to the layers followed by geophysical methods .

3-2. A difficulty appeared to correlate the horizon mapped in the different compartments.

Across the fault F2 : compartments IV and I are tied by means of the traverse PPR 7 . It was assumed that the 4,500 m/sec marker in compartment I and the 4,700 - 4,980 m/sec marker in compartment IV represent very close geological formations . Moreover, the offset spreads confirm that the reflection horizon mapped overlies the above refraction markers by 120-140 milliseconds on both traverses PP7 and PP8 .

Across the fault F 4 :reflection data alone cannot be correlated with security. Assuming that the refraction marker, the velocity of which decreases to 4,500 m/sec on the top, is the same all along the traverse PPR7, it is believed that the reflection horizon mapped between the faults F4 and F3, at a constant distance above the refraction marker, is the same than the one followed in compartment IV and I .

Across the fault F 3 : reflection correlation is quite impossible along the traverse PP 7 . But it is easier when following the traverses K 16 or K 32 and K 13. Then following the previous traverse 5 and the new K 23 one, it appears that the horizon mapped is only 50 to 80 milliseconds above the 4,600 m/sec refraction marker .

The reflection and refraction levels may be not exactly the same than those followed in compartments IV and I but it can be assumed they probably belong to the same geological formations .

The closure of the loop can be made along K 27 across the fault F 2. This lead to consider two other faults at SP 604 and SP 606, downthrown to the north-west, and to a complex knot of faults .

4- GRAVITY (Pl No 21-22)

4-1. Network of bases (Plate No 21)

The network of bases established during the 1963 " PEARCE POINT SURVEY " was basically used and nine new bases were added and tied to it . They are from the north to the south, 406,367,355,470,251,220,227, 10 and 280 . The misclosures found were all inferior to 5 hundredths of a milligal , they were compensated along the new ties without changing anything to the old ones .

4-2 . Bouguer Anomaly (Plate No 22)

The values added during the present survey allowed a better drawing of the map previously presented in 1963 and extended it toward the south and toward the north with traverses K 18-19-20 and 24. The new map at a 1/100.000 scale includes all the values of both surveys calculated with a rock density of 2.1 and is drawn with a one milligal contour interval .

4-3. Discussion of the results

The Bouguer values show a very large negative anomaly covering all the area surveyed .

The central " low" extends along a N.N.E,S.S.W axis and is located along the northern third of PP8,the western part of K 22, PP 11 and the northern part of K 21 .

Towards the west and the south, a rather regular gradient shows an increase of the Bouguer values from - 14 to + 10 ,i.e of 24 milligals .

The north was not surveyed and contours cannot be drawn .

Toward the east the gradient is of 50 milligals along 30 kilometres i.e, an average of 1.7 milligal per kilometre but this gradient is not regular, between SP 471 and 475(traverse K 22) it is of about 15 milligals i.e approximately 5 milligals per kilometre.and along a section perpendicular to the contours just north of K 22, it reaches 6.4 milligals per kilometre .

Westward, a positive anomaly appears north of SP 500, traverse K 22.

But the general oval shape of this very large anomaly is very often disturbed locally by sudden changes of the gradients.

A residual Bouguer anomaly could be drawn by substracting a regional one but the choice of the latter would be rather difficult.

Following another way to study the gravity data the curve of the Bouguer anomaly were drawn along the seismic traverses K 12-K13-K18-K20-K22-K23-K24-K27 and PP7 (Pl 19 a to 19 i) considering, the regional anomaly is easier and the variations of gradient may be correlated with the seismic data.

It appears immediately that the large negative anomaly is not to be correlated with any of the levels followed by the seismic techniques. It is probably tied up to deep events and isostatic effects.

Towards the east, the gradient may partly correspond to the uprise of lower Proterozoic and older levels outcropping in this direction.

Towards the west, the gradient may correspond to isostatic effects due to the vicinity of the ocean and the deeps of the Timor Sea.

On the contrary the irregularities may be correlated to the sedimentary structures, mainly to the faults.

The best example is given by traverses K 22, K 18, K24 where the gravity anomalies A1, A2, A3 correspond to the fault F1, and where the contours are practically perpendicular to the general trend of the fault.

Along K 22 and K 18, the anomaly may be estimated to 14 milligals approximately and the corresponding throw of F1 (h) is roughly given by the formula :

$$h = \frac{\Delta g}{0.0419\, d} = \frac{24\ \Delta g}{d}$$

Where Δg is the value of the anomaly and d the contrast of density.

Considering d = .4 generally adopted in this area :

$$h \# 60 \Delta g$$

h calculated in metres

Δ g calculated in milligals

Consequently the throw across K 22 and K 18 would be approximately 840 metres . With a contrast of density d = .3 it would be 1120 metres .

It appears reasonable to say that the throw of F1, in this area, should be of 800 to 1100 metres .

Across K 24, the anomaly is only of 7 to 8 milligals correspon-ding (for d = . 4) to the 420 to 480 metres , with d = . 3, it would correspond to 560 to 640 metres.

Accordingly the throw should be of 450 to 650 metres, that means it should decrease towards the north .

Further north , it cannot be estimated across K 20 as the traverse was not extended enough towards the south-east and the shape of the eastern part of the anomaly is unknown .

The orientation of the traverse K 23 is too close of the trend of the contours to allow any computation across the complex system of fault F1-F2.

The traverses K 27 and K 12 show an anomaly , A 4, not well delineated along K 27 but that may be estimated to 4 to 5 milligals along K12, i.e to a throw of 250 to 400 metres across F 2.

The variation of gradient along PP 7 and K 13 are very small when crossing the faults F3, F4 and F2. This should mean that the throw of these faults are small but confirm the fact that the compartment between the two faults F 3 and F 4, is sunk in correlation with the other compartments.

PART FOUR

COMPARISON WITH PREVIOUS RESULTS

1 - SEISMIC

The seismic traverses shot in 1963 were re-interpreted during the present survey . Only minor modifications were to be brought to the previous interpretation. However, the deep horizon mapped and called " horizon 3 " appeared to be questionable and not continuous over distances long enough to allow its mapping .

The main change concerns the contour map (Pl 20) summarizing the information relative to a reflector followed all over the surveyed area .

The dense network of seismic lines in the central area permitted to draw a satisfactory picture of the fault systems . Although simplified, this picture fits with the information supplied by other sources .

In any case, the features presented in 1963 on the contour map of horizons 2 and 3 were not secured and " could be deeply changed by further work " as it was stated page 28 of the final report in 1963 .

The present map is, without any doubt, much more detailed and accurate than the schematic map drawn in 1963 from the results of three seismic traverses .

2 - GRAVITY

A brief comparison of the " Bouguer anomaly map " drawn in 1963 and 1964 is made in Part three -4 above .

PART FIVE

ACHIEVEMENT OF OBJECTIVES

Objectives defined in Chapter II were met satisfactorily .

1- The Kulshill structure was delineated .

2- The reflection experiments led to a spread giving, generally speaking, a quality of data better than during the 1963 survey due to three factors .

- Wide surface covered by the geophones pattern ,
- Perpendicular to the traverse offsetting of the shot points pattern .
- Increase of the number of traces allowing a better correlation between traces .

3- Refraction technique was hampered by the topographical irregularities, the dense faulting system. It was nearly impossible to shoot long spread to shot point distances in order to record arrivals from deep markers if they exist .

4- The gravity readings made at each new shot points allowed a more secure drawing of the Bouguer anomaly contours . Thus, it became possible to compare the seismic and gravity data and to show the relation between both technics mainly when crossing the faults .

CONCLUSIONS

The three and a half month survey carried out during 1964 over the Port Keats are of the Oil Permit OP 2, in order to complete the 1963 one, brought a major contribution to the knowledge of the area.

In 1963 , the existence of the Kulshill High was discovered at the end of the survey according to the data along the traverse PP 7 and the south west extension of the traverse PP 8 shot during the last days of the survey .

In 1964, the quality of the recordings was improved , if the area were found very prospective due to the results of the next well to be drilled, some new experiements might be carried out in order to check again if the data could not be improved .

At the present stage , it was possible to delineate rather well the Kulshill structure and its complex system of faults and a drilling location can be defined .

This structure appears well closed all around the top which is strongly faulted, However, the knowledge of the vertical velocities and the identification of the seismic horizons are too limited and fragile to allow an estimation of the thickness of the prospective layers . The complex fault system makes the problem more delicate to solve since the correlations between the different compartments are not perfectly secure .

It seems that drilling north of the fault F 2 would be the best way to extend the knowledge of the horizons to a wide area towards the north and east and maybe to the offshore data .

COMPAGNIE GÉNÉRALE DE GÉOPHYSIQUE

It may be advisable not to drill too close to F2 as the top of the structure may be eroded and a part of the geological section missing .

C. DIKOFF

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S. LEMONDE

Australian Branch Manager

BRISBANE , January , 1965

APPENDICES

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COMPAGNIE GÉNÉRALE DE GÉOPHYSIQUE

APPENDIX I

PERSONNEL

The personnel required by the agreement and present on the party are listed below .

		Basic	Complement. means
1- SEISMIC PARTY			
Office	Party Leader	1	
	Seismologist	1	
	Computer	1	
	Administrative assistant	1	
Surveying			
	Surveyor	1	
	Helpers	3	
Recording			
	Observer	1	
	Junior observer	1	
	Assistant	1	
	Shooters	2	1
	Helpers	8	
Drilling			
	Field Manager	1	
	Drillers	2	1
	Helpers	2	1
	Mechanic	1	
	Assistant Mechanic	1	
Gravity			
	Gravity operator		1

		Basic	Complement. means
Camp			
	Camp boss	1	
	Cook	1	
	Helpers	2	
	Driver	1	
	TOTAL	33 + 4 =	37

The Party Leader, the Seismologist, the Surveyor and the Observer were expatriated from France, the rest of the personnel was hired in Brisbane.

2- CIVIL ENGINEERING PARTY

Two Bull dozer operators and one driver were supplied by Monk (Darwin) at the beginning of the Party. One operator was added the last month when a more intensive work was necessary .

COMPAGNIE GÉNÉRALE DE GÉOPHYSIQUE

APPENDIX II

EQUIPMENT

1 - VEHICLES

Office

- 1 Land Rover ,109 inches

Surveying

- 1 Land Rover ,109 inches

Recording

- 1 Recording truck International 160 ,four wheel drive
- 3 Land Rovers (cable carriers)
- 2 Land Rovers (shooting trucks) + 1 (complementary means)

Drilling

- 2 International 190 four wheel drive drilling trucks
- 1 International R 190 4 x 4 ,equiped with two 800 gallons water tanks
- 1 Land Rover ,109 inches

Camp

- 1 International 160 4 x 4 Supply truck

Gravity

- 1 Land Rover ,109 inches (complementary means)

Note : The following vehicles were in stand by at the camp :

- 1 International 190 four wheel drive drilling truck
- 1 Land Rover ,109 inches
- 1 Land Rover ,109 inches was kept at the disposal of AAP.

2 -CAMP

The camp consisted of :

- 2 air conditioned trailers : office and kitchen
- 1 workshop trailer
- 1 power plant trailer with two 18 KVA plants

- 10' x 10' and 20' x 20' individual and collective tents .

3-SPECIAL EQUIPMENT

3-1 Surveying

- 1 Wild To Theodolite
- Staffs, compasses, binoculars

3-2 Recording

- One recorder Type C.G.G. 59 with a pulse width modulated magnetic recording. Sequential field play-back facility with the C.G.G. MTD corrector allowing for variable area or wriggly line reproduction .
- 1 SIE-PRO 11, 25 traces, photographic recorder
- 1 set of 24 C.G.G. refraction filtres
- 2 C.G.G. SBT 1000 automatic blasting boxes ,1000 V output, equiped for radio transmission of the time break
- 1 C.G.G. manual blasting box

3-3 Geophones-Reflection

- 900 Hall Sears Junior geophones 20 c,p,s, 245 ohms on jumpers of 12 with 15'intervals. Geophones are connected in parallel on the jumpers.

Refraction

- 300 Hall Sears refraction geophones, 215 ohms ,4,5 c.p.s 3 geophones are connected in parallel on a jumper.

3-4 Cables

Reflection

- 9 portable cables with 3 take outs by cable allowing for recording of 24 traces with up to 200' between traces.

Refraction

- 27 helicoidal portable cables, 1000 feet long with one take-out by cable.

One weathering zone special cable with 24 take-outs, one HS-J geophone per take out.

3-5 Radio

- 4 VHF " PYE Ranger" type, frequency modulated, with attachments for radio transmission of the shot instant.
- 1 HF PYE transmitter receiver for communication with the Royal Flying Doctor Service network.

3-6 Drilling

- 2 Mayhew 1000 equiped for air/water drilling (+ 1 in stand-by)
- Air compressor Gardner Denver W x H type 100 p.s.i.
- Mud pump Gardner Denver 5" x 6" 895 p.s.i.
- Derrick height = 22 feet
- Drilling pipes : 20 x 15 feet

3-7- Engineering

- 1 Caterpillar D 7 Bull dozer
- 1 Caterpillar HD 8 Bull dozer
- 1 Rover and one Willis for transportation of operators and supplies.

3-8 Gravity

- One Worden gravitymeter, Pioneer type , No 41

APPENDIX III

HISTORY AND STATISTICS

All figures concerning the statistics of the survey are presented on Fig 3.

1-HISTORY

1-1 Seismic

The main events of the survey are recalled hereunder :

- Begining of the surveying and dozing	7 th of July
- First drilling	11 th of July
- First seismic shot	12 th of July
- Last drilling	24 th of October
- Last shot	26 th of October

On the twenty seventh of October the Party left OP 2.

1-2 Gravity : (see Fig 3)

2- STATISTICS

2-1 Seismic Statistics

The contract called for 190 hours of production per month, but due to the short time available before the beginning of the wet season, it was decided after discussion with the client to increase that amount. The average worked hours for the 4 months was 255 hours per month. Production was improved compared with the " PEARCE POINT SURVEY 1963 ". This was mainly due to a better knowledge of the working conditions in the permit and an increase of the equipment potentiality . Considering the great difficulties in supplying spare parts for the vehicles and the drills on this permit, one Mayhew and one Land Rover were kept in stand-by in order to have enough equipment on the field in case of a break down .

In Reflection work 0.75 spread per hour and 0.47 new kilometres were carried out per production hour .

In Refraction, the average production was of 0.65 spread and 0.36 km per hour. The above production were affected by several changes of program and travelling difficulties .

2-2 Drilling Statistics

Two drills were used , one was in stand-by. The average production was 211 feet per hour .

The drilling was generally done by air in soft formations, except in the open plain where water had to be used .

2-3 Dozing Statistics

21% of the total dozing time was spent in travelling. The travel was reduced during the last two months when a better knowledge of the program allowed a better work planning .

2-4 Gravity Statistics

Calibration of the gravitymeter was done in Brisbane on the 7 th August 1964.

The first results on the field were obtained on the 26 th August 1964 .

Last readings were made on the 11 th October 1964, during this period :

- 9 new bases were established
- 532 new and 47 repeated stations were measured
- a total of 677 readings were made .

APPENDIX IV

EXPERIMENTAL WORK

1- OBJECTIVES

According to the results obtained during the PEARCE POINT SURVEY in 1963, it was decided to carry out some experiments during the first week of the survey in order to try to improve the quality of the arrivals recorded.

It was expected that an increase of the number of geophones per trace, of the number of holes or of the surface covered either by the geophones or the shot point pattern would improve this quality. However, for economical reasons, it was decided not to exceed a number of 60 geophones per trace.

It was also expected that deeper reflections might be recorded (if they were existing).

2-PARAMETERS STUDIED

The 1963 PEARCE POINT SURVEY had demonstrated the high value of patterns of shallow holes used as shot -points. Consequently it was decided not to experiment again deep holes but to use only shallow holes.

The parameters studied were :

- Number of geophones per traces
- Pattern of the trace (density, surface, shape etc...)
- Number of holes per shot point
- Pattern of the holes (density , surface , shape , etc...)

3- TECHNIQUE SELECTED

The following principles were followed:

- One parameter only must be changed from one shot to the other

FIG.4a.

55

GEOPHONE PATTERNS

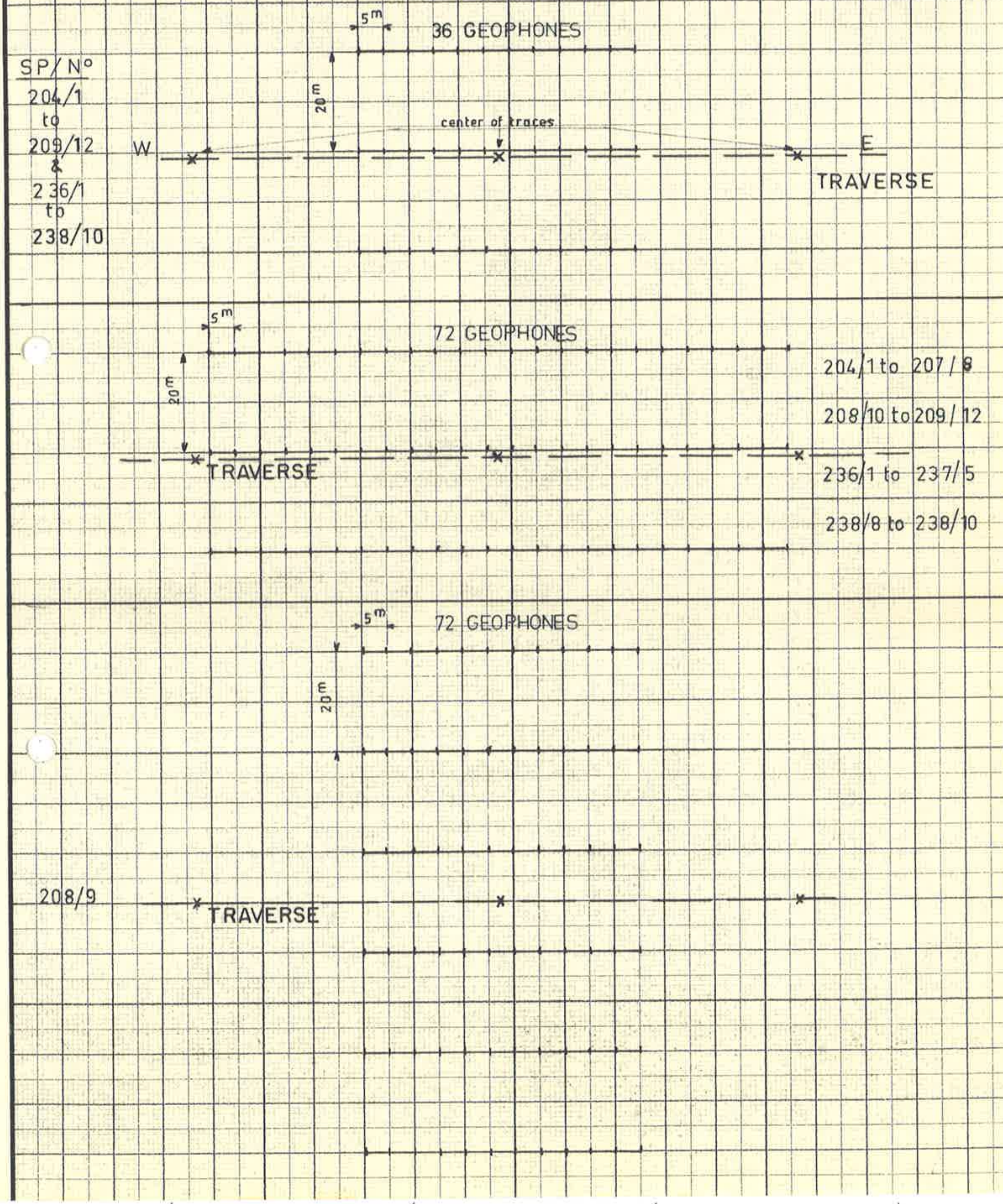


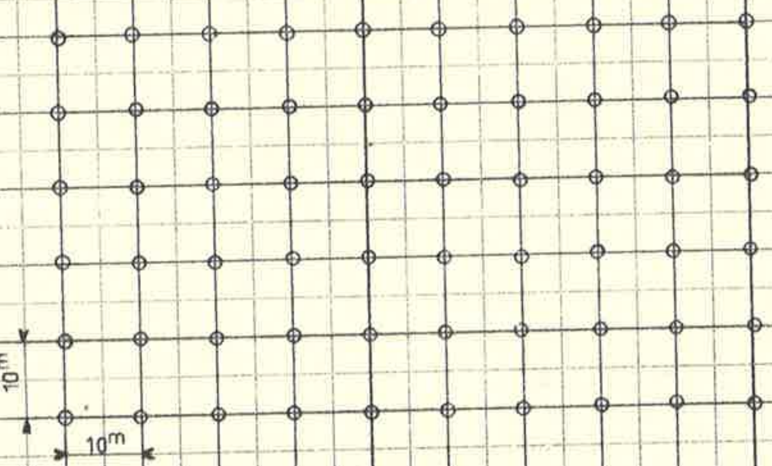
FIG. 4b.
56

HOLE PATTERNS

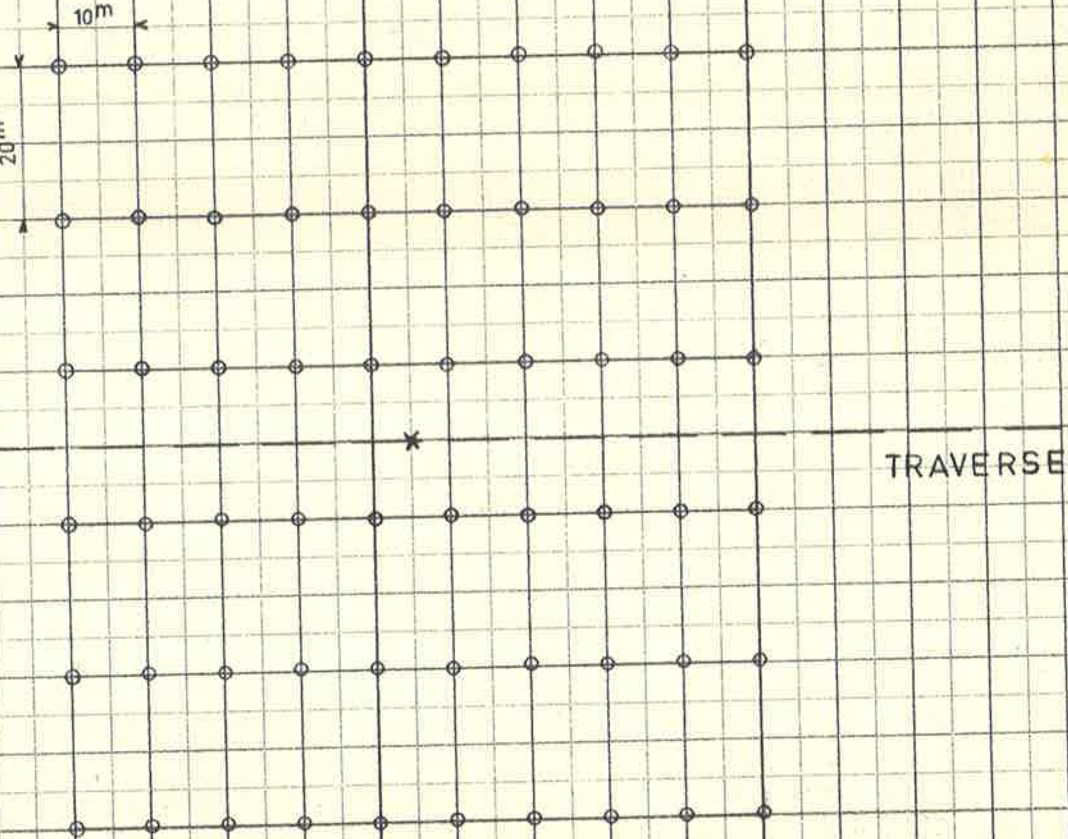
SP /N°

204/1
205/4
206/5
207/7
208/9
236/1
237/4

60 HOLES



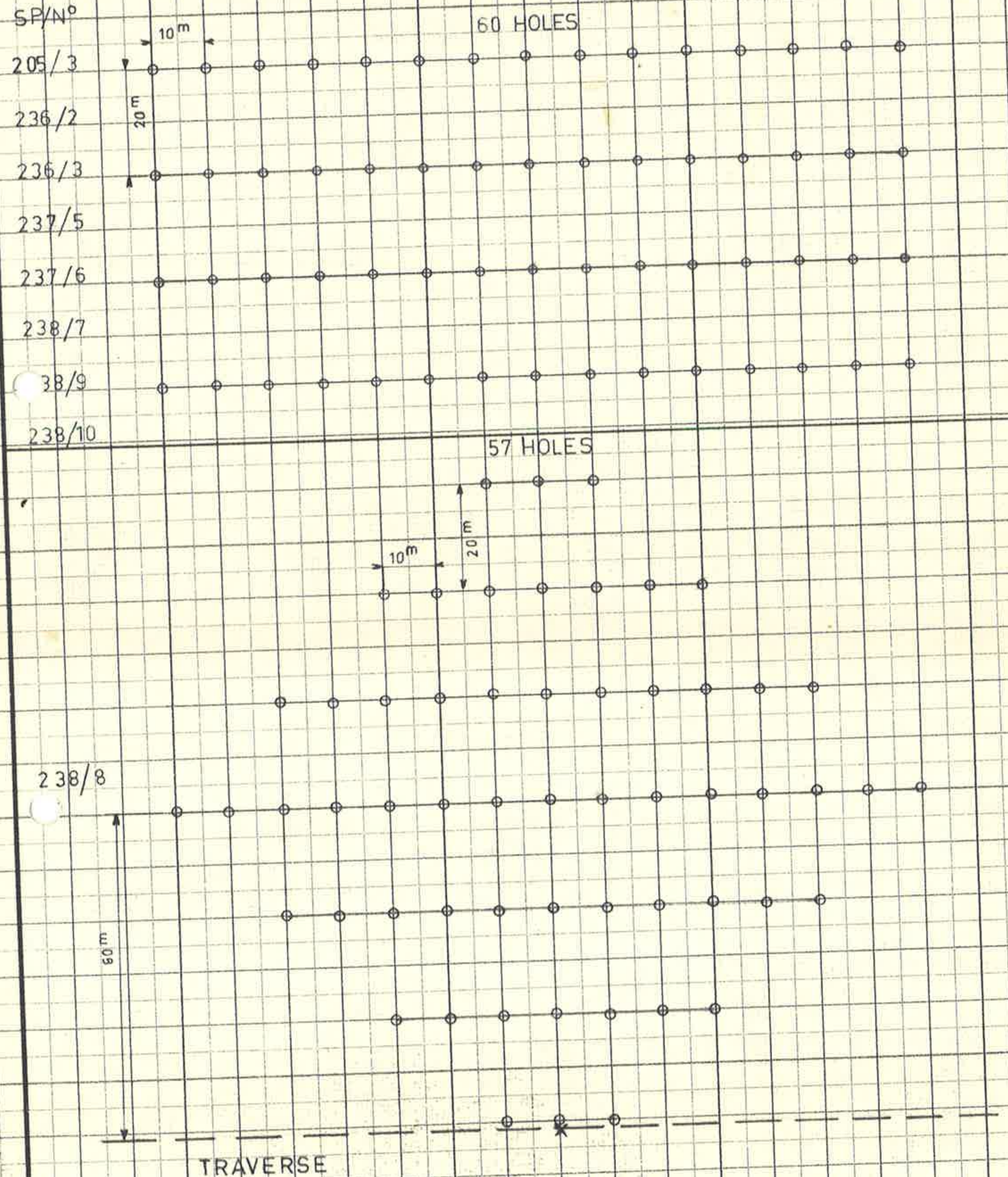
60 HOLES



206/6
209/11

FIG.4c
57

HOLE PATTERNS

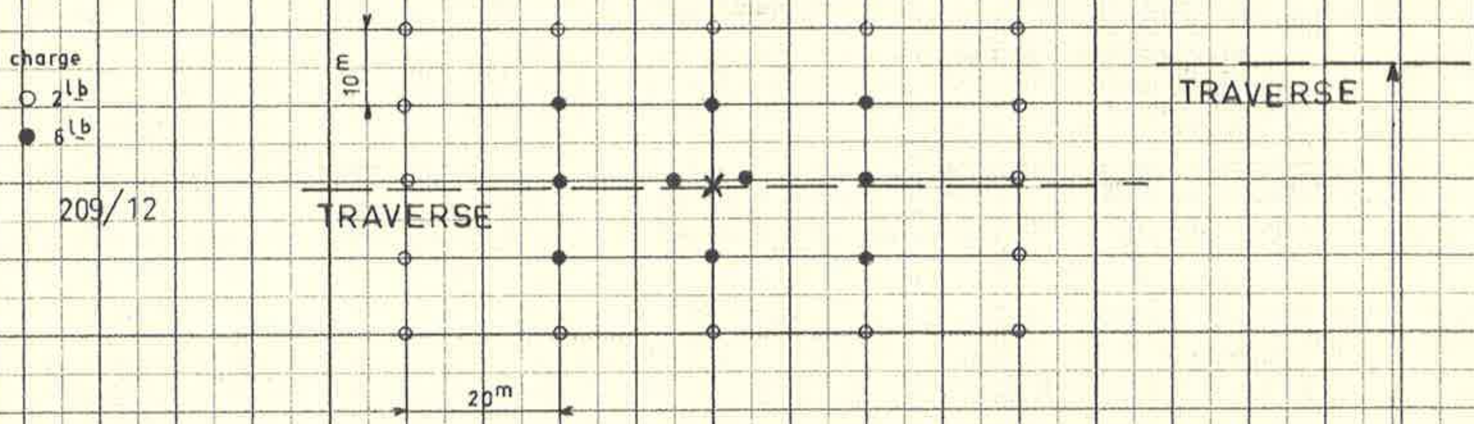


Diamond pattern equivalent to weighted linear pattern //profile
(Weights 1-1-3-3-5-5-7-7-7-5-5-3-3-1-1).

FIG. 4d.

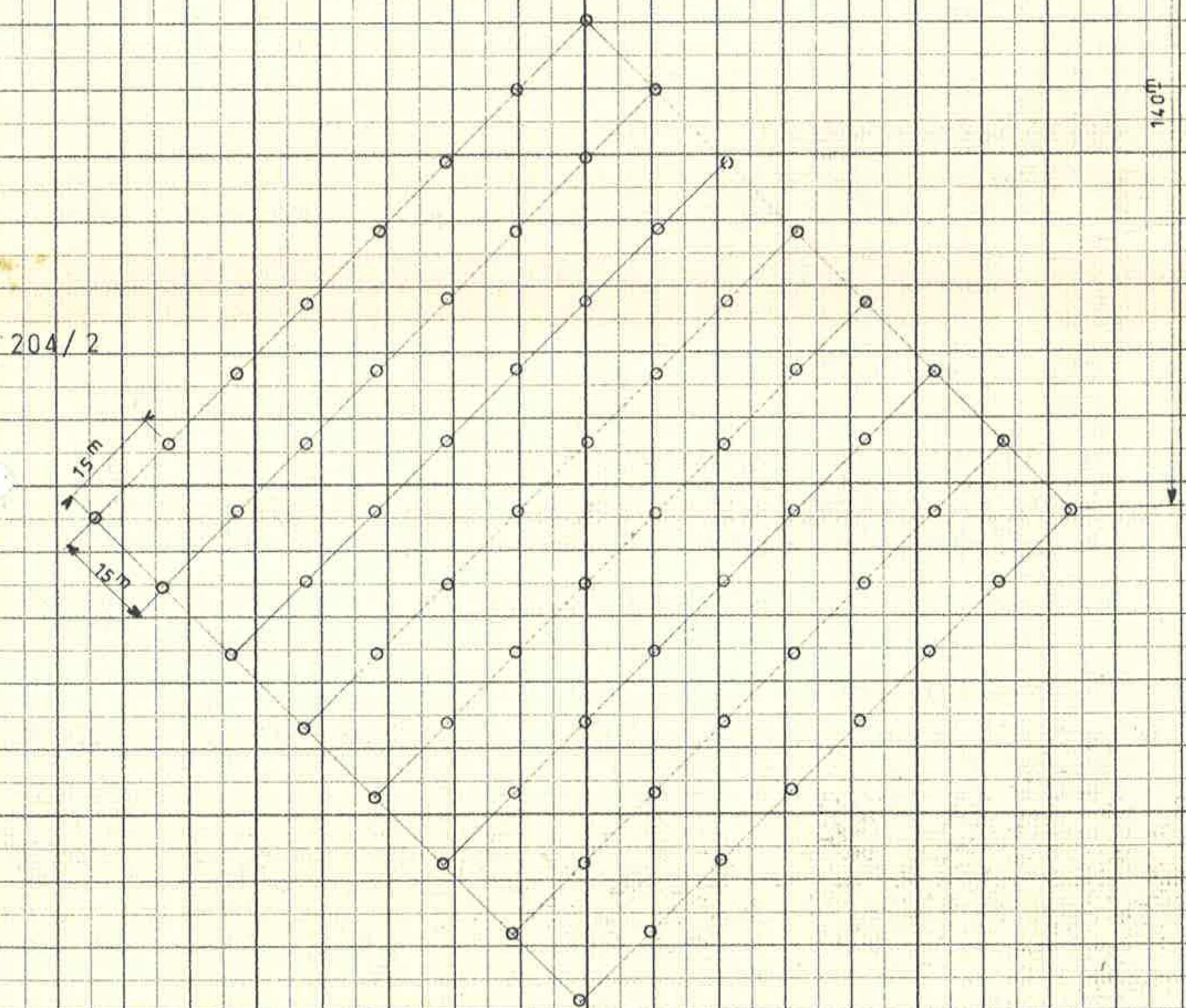
58

HOLE PATTERNS



Weighted charges equivalent a dispositif. 10-22-28-22-10 //profile.

64 HOLES



(1-2-3-4-5-6-7-8-7-6-5-4-3-2-1)

A.A.P. EXPERIMENTS

FIG. 4e:
C.G.G.
59

Permit: OP 2 — Survey: Kulshill — Traverse: K12

No.	S.P. (West ← / East →)	Offset	Depth	Charge	Filter	Recording	Hole Pattern	Geophone Pattern	X	e	Remarks
I	204→	35 S	I0 ft	I80 lb	I/I4	AGC medium	6 x I0	36 & 72	720	60&I20	
2	204→	I40 S	"	"	"	"	8 x 8	"	"	"	Diamond
3	←205	65 N	"		"	"	4 x I5	"	"	"	
4	←205	35 S	"	"	"	"	6 x I0	"	"	"	
5	206→	0	"	"	"	"	6 x I0	"	"	"	
6	206→	0	"	"	"	"	6 x I0	"	"	"	
7	←207	0	"	"	"	"	6 x I0	"	"	"	
8	←207	0	"	240	"	""""	I2 x I0	"	"	"	
9	208→	0	"	I80	"	"	6 x I0	"	"	"	(72 geoph
I0	208→	0	"	"	"	"	3 x I0	"	"	"	on 6 row
II	←209	0	"	"	"	"	6 x I0	"	"	"	
I2	←209	0	"	92	"	"	[illegible]	"	"	"	

TEST OF GEOPHONES PATTERN

Comparison between 36 geophones/trace and 72 geophones/trace in 3 lignes layed on the same spread. (shots I to 8)

The best results are obtained with the 72 geophones/trace.

Comparison between 36 geophonos/trace and 72 geophones/trace in 6 lignes layed on the same spread (shot 9 to I2)

The best results are obtained with 72 geophones/trace.

CONCLUSION

A slight improvement seem to be obtained with 72 geophones/trace

TEST OF HOLES PATTERN

Comparison of shot I with 2.

The diamond pattern with offset I40^{m} show an important improvement in the quality of the deep reflections. But it is not know whother the improvement is due to the shape of the pattern or to the offset only.

Comparisòn of shot 3 with 4 (6xI0 holes and 4xI5 holes offset 65^{m})

slight improvement with the pattern 4xI5 holes offset 65^{m}

Comparison of shot 5 with 6 (I0^{m} between lignes and 20^{m} between lignes)

The pattern with 20^{m} between lignes seem to give a best result.

Comparison of shot 7 with 8 (6xI0 holes and I2xI0 holes)

A important part of detenaters didn't work during the test.

X = Distance between S.P.'s.
e = Distance between traces

FIG. 4e.
C.G.G.
60

A.A.P.

EXPERIMENTS

Permit: OP 2 | Survey: Kulshill | Traverse: K 14

No.	S.P. West / East	Offset	Depth	Charge	Filter	Recording	Hole Pattern	Geophone Pattern	X	e	Remarks
I	←236	35 S	I0 ft	I80 lb	I/I4	AGC Medium	6 x I0	36 & 72	720	60 & I20	
2	←236	I30 N	"	"	"	"	4 x I5	"	"	"	
3	236→	40 N	"	"	"	"	4 x I5	"	"	"	
4	←237	35 N	"	"	"	"	6 x I0	"	"	"	
5	237→	50 S	"	"	"	"	4 x I5	"	"	"	
6	237→	I30 S	"	"	"	"	4 x I5	36 & 48	"	"	
7	←238	40 S	"	"	"	"	4 x I5	36 & 72	"	"	Diamond
[illegible]	←238	60 N	"	I7I	"	"	57	"	"	"	
9	238→	40 S	"	I80	"	"	4 x I5	"	"	"	
I0	←238	I20 S / 720 E	"	"	"	"	4 x I5	"	"	"	

TEST OF GEOPHONES PATTERN.

Comparison of 36 geophones/trace in 3 lignes with 72 geophones/trace in 3 lignes layed on the same spread.

Tests No I,2,3,4,9,I0 slight improvement with 72 geophones/trace

No 5,7,8 very slight improvement with 72 geophones/trace

No 6 comparison of 36 gephones/trace with 48 geophones/trace same quality of results

CONCLUSION

The best results seem to be obtained with 72 geophones/trace

OFFSET TEST.

Comparison shot I with 2

The offset shot I30 m show a slight improvement in the quality of the deep reflexions.

Comparison shot 5 with 6

The offset shot I30 m show a fair improvement in the quality of results.

Comparison shot 4 with I0

The weakness of the shot made comparison impossible

CONCLUSION

The best results are obtained with offset shot without difficulty to implant the hole pattern.

X = Distance between S.P's.
e = Distance between traces

- Arrivals are recorded along a reference spread and simultaneously along a comparison spread.
- Comparisons are conducted from a reference shot point.

In order to obtain these results the " fold-back spread" was used: One cable 12 traces is laid out with a reference geophone pattern (60 metres between traces, 36 geophones per trace), and the second cable is laid out parallel to the first one with another geophone pattern (6 traces spaced 120 metres, 72 geophones per trace for example)

4-FIELD OPERATIONS

Experiments were conducted according to the instructions given by A.A.P, along traverses :

-K 12 : SP 204 to 209

-K 14 : SP 236 to 238

in the central part of the survey, close to the culmination of the Kulshill High (see Fig 1)

Locally and during the course of the survey, some spreads were reshot in order to check if the pattern and charge currently adopted gave the best results .

The different geophone patterns used are indicated on the figure 4 a . The different hole patterns shot are shown on the figure 4 b, 4 c and 4 d. In every case, the number of the shot-points where a given pattern was used is indicated.

The Figure 4 e is a summary of the experiments carried out .

The records are presented on Plates 23 and 24 on which are shown also the main parameters for each shot .

5- CONCLUSIONS

It appears rather difficult to draw very reliable conclusions from these experiments. Further seismic work showed that the main reason is that they were carried out in an area of complex and faulted tectonics and close to the top of the Kulshill high .

However, the following points may be put forward :

- The 60 metres spacing between traces allows a better correlation than the double 120 metres spacing .
- The improvement given by 72 geophones per trace compared to 36 seems to be very slight .
- But the total surface covered by the geophones pattern appears as an important factor .
- An increase of holes per shot-point improves the results .
- Also a perpendicular to the traverse offset of the shot-point improves the quality of the recordings .

Following these experiments the following spread was adopted :

- Distance between traces 60 metres .
- 36 geophones per trace, in 3 lines parallel to the traverse (Fig 4 a), 5 m between geophones, 20 m between lines, the surface covered (2,200 square metres) being the same as the one covered by the pattern used during the 1963 " Pearce Point Survey " but with only 36 geophones instead of 60. This fact allowed an important increase of the output .

The shot-point consisted of 60 holes in 4 lines of 15, parallel to the traverse, (Fig 4 b) with a perpendicular to the traverse offset of 130 metres .

These characteristics take into account :

- The results of the experiments,
- Economical reasons (36 geophones instead of 72)
- Production conditions : it is easier to clear with a bulldozer 4 lines of 15 holes than 6 lines of 10 holes , although the cleared lenght is the same in both cases .

COMPAGNIE GÉNÉRALE DE GÉOPHYSIQUE

APPENDIX V

TECHNIQUE

1- REFLECTION

1-1. Continuous profiling

The reflection method used during the survey was the coventional split spread recording. Twenty four recording stations are laid out and the shot is fired mid-way between stations 12 and 13 .

Half of the spread ,i.e. twelve recording stations are then shifted forward and the next shot is fired in the middle of the spread .

1-2. Offset Shots

Consecutive reflection spreads are recorded from a given shot point up to a distance where the reflected events are replaced by refracted arrivals. Reflection instrumental settings are used for the centre and the first offset spreads. Then refraction instrumental settings are used .

These spreads allow a correlation of reflection and refraction events .

2- REFRACTION

2-1. Refraction probe

A probe consists in recording a certain number of consecutive refraction spreads laid down between two fixed shot points . This allowed two time-distance curves to be plotted : one called " direct" and one called " reverse " according to the location of the shot in respect to the recording spreads. An inventory of the markers is made, each marker being characterized by its horizontal velocity . For this survey the distance between the shot points, which varies with the depth to be investigated, varied from 8.5 to 14 km .

2-2. Continuous profiling

The Gardner -Layat method of continuous profiling has been used by C.G.G. since 1952. This method is modified and adapted from L.W. Gardner " An aerial plan of mapping subsurface structures by refraction shooting " (Geophysics 1947, Volume XII, page 221). Recording is conducted with twenty four recording stations. After completion of the shots at one location twelve recording stations are shifted forward .

The result of the computation is a delay time curve. Thedelay-time is easily converted into depth using the formula :

$$\text{Depth} = K \times \text{delay} \times \frac{V}{\cos\theta}$$

With K = anisotropy factor

V = overburden velocity

$\sin\theta$ = overburden velocity/marker velocity

3- GRAVITY

3-1. Network of bases

9 bases were added to the previous network settled during the 1963 " Pearce Point Survey". All are located at seismic shot points.

3-2. Stations

All the stations were located at the seismic shot-points and the duration of the programmes, i.e. readings at a base, at stations and at next base was always inferior to 4 hours in order to control the drift of the apparatus.

For the same reasons, readings at certain stations were repeated in order to control the quality of the readings and the evolution of the gravity meter.

A total of 532 gravity stations were determined, 47 of which were repeated: i.e.: 9%-81% of the repeated stations show a difference inferior or equal to .04 milligals.

APPENDIX VI

FIELD OPERATIONS

1-POSITIONING AND WITHDRAWAL

With the 1963 " Pearce Point Survey" experience, positioning and withdrawal were considered possible :

- by tracks for all vehicles,
- by barges for the trailers,

A dozer was sent 10 days ahead of the convoy to open a track, particularly in the river beds, between Daly River and Port Keats. A grader was also used at the beginning, the convoy however was bogged one day 40 miles from Daly River and the bulldozer had to be called back to pull the heavy vehicles out.

The withdrawal was made in better conditions following a dry spell in weather one week before moving. A bull dozer followed the convoy in case of emergency but was not used.

2- CAMPS (see Fig 1)

A main camp situated 6 miles south of the Port Keats Catholic Mission, at the intersection of three trails was used as base camp for the majority of the traverse exploitation. Two fly camps CS1 and CS2 were established for the exploitation of the northern part of the survey. The two fly camps were settled without interruption in the normal routine of the party.

3- LOGISTICS

3-1. Water Supply

Fresh water supply was taken from the Kulshill Creek near the main camp. When water was needed for drilling purpose it was taken from the nearest water point. Travelling distances did not exceed 7 to 8 miles.

3-2. Food Supplies

Perishable foodstuffs were delivered weekly to the Catholic Mission by a chartered plane (6 miles from the main camp) .

Tinned foodstuffs were delivered by supply truck fortnightly, a first stock being sent at the beginning of the survey by barge .

3-3 Fuel, Lubricants and explosives

The main supply was made by barge at the start of the survey, the complement was delivered by road at the end of September .

4- COMMUNICATIONS

3 Daily sessions were established with the Royal Flying Doctor Service.

2 daily sessions with A.A.P allowed to send directly all technical information using a single band radio transmitter .

5- BULL DOZER

2 bulldozers HD 7 hired by A.A.P from G. MONK in Darwin worked for the party for the opening of traverses and shot point patterns.

2 operators were in charge of the bulldozers, a Land Rover and a driver supplied also by G. Monk did the general supplying. Food and fuel were bought at the main camp.

At the end of the survey a third operator was added and a HD 7 bulldozer was replaced by a HD 6.

6-SURVEYING

6-1 Basic documents

The basic documents were the location map, and the survey books of the previous 1963 survey. A complete set of aerial photographs, reduced photomosaics and photo maps at approx. scale 1/48.000 were supplied by A.A.P and gave a very valuable help .

6-2. Pegging

Reflection: 12 traces at 60 metres were flagged between two successive shot points. The shot point spacing was 720 metres.

The profile location was established close to the proposed location after a study of the aerial photographs and photomaps.

Refraction: 24 traces spaced 180 m along K 22 est
24 traces spaced 120 m along K 22 west and center
24 traces spaced 100 m along P P R7

6-3. Levelling

A Theodolite To and two metric staff were used. The distance between each sight was generally 180 metres (3 traces) .

6-4. Closures and ties (see Pl 2)

All traverses were tied to the 1963 network. The loops were included in this network and the misclosures are indicated on Pl 2.

Calculated co-ordinates were not compensated. Calculated elevation were compensated .

6-5 . Projection system

The Universal Transverse Mercator projection (Zone 6 Australia series) was adopted . Co-ordinates and elevations were calculated in the metric system.

6-6. Permanent markers

10 feet long iron pipes were placed along the lines approximately every 10 reflection shot points. The name of the traverse and the shot point number were carved on the pipes .

Their location is indicated on the location maps at a scale of 1/50,000 and 1/100,000. A list of the permanent markers with the corresponding co-ordinates and elevation is given at the end of the Appendices .

6-7. Documents supplied

- Location map at a scale of 1/100.000 with a plot of the previous survey's traverses (Port Keats 1961- Pearce Point 1963).

- Location accessibility maps at a scale of 1/50,000 with a plot of seismic and gravity traverses of the above surveys, and the main topographic features. The principal access trails were also indicated.

7-DRILLING

Drilling was conducted with 2 Mayhew 1,000 air/water rotary drills. Insert bits 5 5/8" were used to a Kelly depth (10 feet). 4 3/4" insert bits were used for deeper drilling .

Water drilling was used in the open plain and in some swamps. Holes were drilled to a depth of 10 feet in reflection and 30 to 60 feet in refraction .

A sample of the cuttings was taken systematically at each shot point .

8-SHOOTING OPERATIONS

8-1. Reflection (Fig 4b)

The reflection shot point pattern consisted of 60 holes in four rows of 15, with 10 metres between holes, 20 metres between rows. The lateral offset was 100 metres, the hole depth 10 feet. The total charge per shot point : 120 or 180 lbs depending on the seismic results .

8-2. Refraction

The refraction shot point consisted of one or several holes at a depth of 30 or 60 feet according to the charge used. Holes were drilled on a line perpendicular to the traverse, the distance between holes was 5 metres.

The charges varied for a given shooting distance not only from traverse to traverse but also between "direct" and "reverse" shots (K23-PPR7). The charges, the recorder gains and the quality of the records are shown on the operational diagrams (Pl 5).

8-3. Special spreads

For the offset spreads a reflection shot point pattern was used for the centre shot and the first offset shot, and refraction shot points for all others.

8-4 . Explosives

Explosives used :

- Nitramon in 1 lb water proof tins manufactured by Dupont de Nemours requiring the use of a 1 lb primer (manufactured by the same firm) .
- Detonators : 30 feet Submarine manufactured by I.C.I.

9- RECORDING

Filters and recording parameters were determined following the experiments made during the first week.

9-1. Reflection work (Fig 4 a)

- Distance between shot points : 720 metres.
- Distance between traces : 60 metres .
- 36 geophones per trace, in 3 lines, 20 metres apart.
- Distance between geophones : 5 metres.
- Lateral offset of the shot point pattern : 100 metres .

9-2. Refraction work

a-Refraction probe

Recording was conducted on two consecutive bases, that is 24 traces with the following parameters :

- Distance between traces 180 metres K 22 east and 120 metres on all other probes to improve the quality of the information.
- Composition of a trace : 12 geophones on 4 jumpers of 3 connected in parallel-series. The geophones were systematically buried and laid out in four lines perpendicular to the traverse. The distance between lines was 3 metres and 10 metres between geophones .

b-Continuous profiling

Exploitation of PPR 7 was continued westwards until the crossing with PPR 8. The new shots 7 (see Pl 12) were to allow the interpretation of a 4,800 m/s marker using the shortest shooting distance.
- 2 long distance shots added to check the possible existence of a deeper marker.

The distances between traces was 100 metres for homogeneity with the work conducted on PPR 7 and PPR 8 the previous year .

9-3. Special shots

a- Offset spreads

The parameters were :

- Distance between traces : 50 metres on PP8, 60 metres elsewhere .
- The geophone pattern used was the reflection pattern .

The shot point was :

- Reflection type for the centre shot and the first offset shot .
- Refraction type for all other shots .

b-Weathering shots

Such shots were carried out systematically every 10 reflection shot points. A special symetrical geophone cable with 24 outlets was used, - distances between traces were :

- Trace 1 to 6 : 5 metres
- Trace 7 to 10 : 10 metres
- Trace 11 to 14 : 20 metres
- Trace 15 to 18 : 10 metres
- Trace 19 to 24 : 5 metres

Each trace consisted of a reflection HS Junior geophone. One shot was taken at each end of the spread, 5 metres away from the first trace .

9-4. Value of the parameters

Reflection

Filters : 1/14 - out

	AGC	:	Medium
	(IG	:	- 30 db
Suppression	(delay	:	280 milliseconds
	(FG	:	Maximum
	(IG	:	-24 to -27 db
Expander	(slope	:	120 db/octave
	(delay	:	400 to 600 msec

b- Refraction

Filters	:	Out - 1/40
AGC	:	Out but for the centre shot (Medium)
Gain	:	-24 to -40 db

c-Special shots

Offset : The two first shots (centre and first offset shot were fired with reflection settings. The third shot with reflection filters without AGC, the following ones without AGC and open filters .

Weathering zone : open filters and AGC : medium .

10- PLAY BACKS:

For reflection and refraction the recording was simultaneously made on :

- Magnetic tape Carter type,
- Film 6" wide, paper speed 8"/ second (galvanometric monitor)

Magnetic tapes were played-back on electro- sensitive paper (width 4", paper speed 7,5 " / sec).

10-1. Reflection

The play-backs were used for determining static and dynamic corrections, to be used for the presentation of corrected record sections.

10-2. Reflection MTD section

Magnetic tapes were processed at the camp. Play-back were corrected for static and move-out corrections and assembled in variable area cross-sections corresponding to ten shot points, with an 1/28 -1/56 filter setting and medium AGC .

Horizontal scale : 1/8,000

Vertical scale : 7.5 inches for one second two-way time .

10-3. Refraction

Play-backs were used to check the quality of the magnetic recording. The pen gain was chosen to obtain a correct amplitude of the trace and was kept constant for each tape .

11- GRAVITY OPERATIONS

The spacing between measured stations was chosen equal to the reflection shot point spacing : 600 metres .

The operator's programme, including readings at a "departure" base, at intermediate stations and at an " arrival" base was prepared in order not to exceed a 4 hour duration .

The network of gravity bases established in 1963 (Pearce Point Survey) was used, new bases being calculated only in the northern and southern p part of the survey where the existing network was considered unsufficiently dense (Pl 22) .

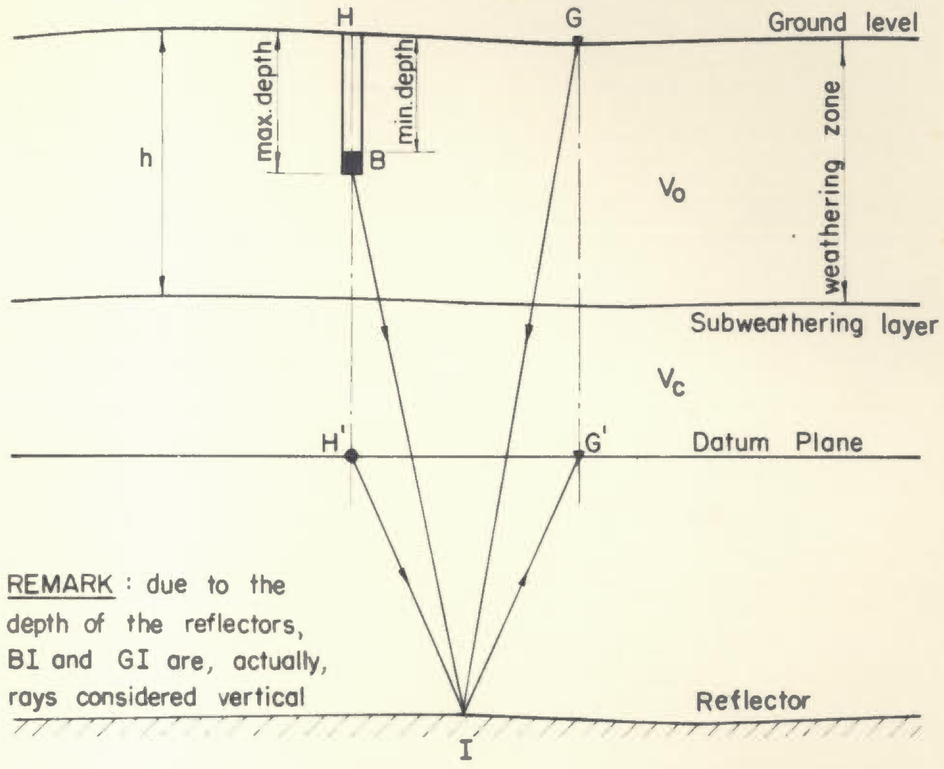
As the bases and stations were located at seismic shot points, the operator had no special flagging to settle on the field and the Bouguer anomaly were computed using the altitude given by the seismic surveyor.

Consequently, the latter carried out his work with a higher precision than the normal one necessary for seismic surveys in order to match the precision of a gravity survey .

Five gravity bases(at SP 280 - 10-251-227 and 367) were located on the field with permanent markers, the 4 others being at seismic shot points where permanent markers were fitted previously .

FIG. 5.

REFLECTION CORRECTIONS



E_H = Elevation of shot point H
E_G = Elevation of the nearest geophone G : generally $E_H = E_G$
D.P. = Elevation of datum plane
V_o, V_c and h given by the weathering shots

(1) Correction at geophone G

$$C = CS + VT \qquad CS = C_{EG} + C_{WZG}$$
$$VT = \text{up-hole time}$$

$$C_{EG} = \frac{DP - (E - \text{min. depth})}{V_c} = \frac{b}{V_c} \qquad C_{WZG} = (h - \text{min depth}) \left(\frac{1}{V_c} - \frac{1}{V_o}\right)$$

(2) Correction at shot point H

$$CPE = C_{EB} + C_{WZB}$$

$$C_{EB} = \frac{DP - (E - \text{max. depth})}{V_c} = \frac{a}{V_c} \qquad C_{WZB} = (h - \text{max. depth}) \left(\frac{1}{V_c} - \frac{1}{V_o}\right)$$

(3) Total correction

$$\Sigma C = CPE + CS + VT$$

C. G. G. 59

Line :
SURVEY :
Party :
Client :
Shot point :

Tape No.
Charge :
Shot No.
Filter : HS-14-20-28 1 2
Date
A.G.C. : slow, med., fast.
Geoph./trace
Expander Gi Po R
Offset
Suppressor Gi Gf R

Tie
D =
d =

Remarks :

PLAYBACK
Playback No.
Filters L.C. H.C.
Pen gain :
Play gain :
A.G.C. : O, slow, med., fast

S P
D =
Z =

Elev. hole E_H D.P. geoph. E_G D.P.
Max. depth Min.
a = b =
$CPE = \frac{a}{V_c}$ = / $CS = \frac{b}{V_c}$ =

V calcul. :
V adopt. :
Remarks :

	CPE	CS + VT	ΣC	CT	ΣCF	Holes
Sup.						
Mid.						
Inf.						

Tie
D =
d =

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

APPENDIX VII

REDUCTION AND PRESENTATION OF DATA

1- REFLECTION STATIC CORRECTIONS

1-1. Origin of information

Information were supplied :

- By the study of the first breaks of the reflection records. They provide values of the sub-weathering layer velocity (Vc) and intercept time ,
- By the special weathering shots, i.e. shallow refraction shots conducted along all traverses using a special cable (see Appendix V-9-3). These shots provide values of the weathering zone velocity (Vo) and give a confirmation for the Vc values .

1-2. Parameters values

The Vc values are around 2,200 m/sec. For the elevation correction, it was adopted Vc = 2,000 m/sec, since this is a vertical velocity which can be slightly inferior to the horizontal velocities measured on refraction arrivals .

The weathering zone consists of a low velocity medium: Vo = 500 m/sec and sometimes of an intermediate layer showing velocities around 1,300 m/sec.

The mean sea level was chosen as reference level .

1-3. Computation of static corrections

The correction computation process is schematically given on Fig 5 together with a model of reflection record label.

This process applied to the nearest geophone to each shot point.

For the other recorded stations static corrections were determined using a method based on the comparison of templates recorded on a spread shot from two adjacent shot points :"Plus-minus method of interpreting seismic refraction sections"(Geophysical Prospecting Vol7. No2)

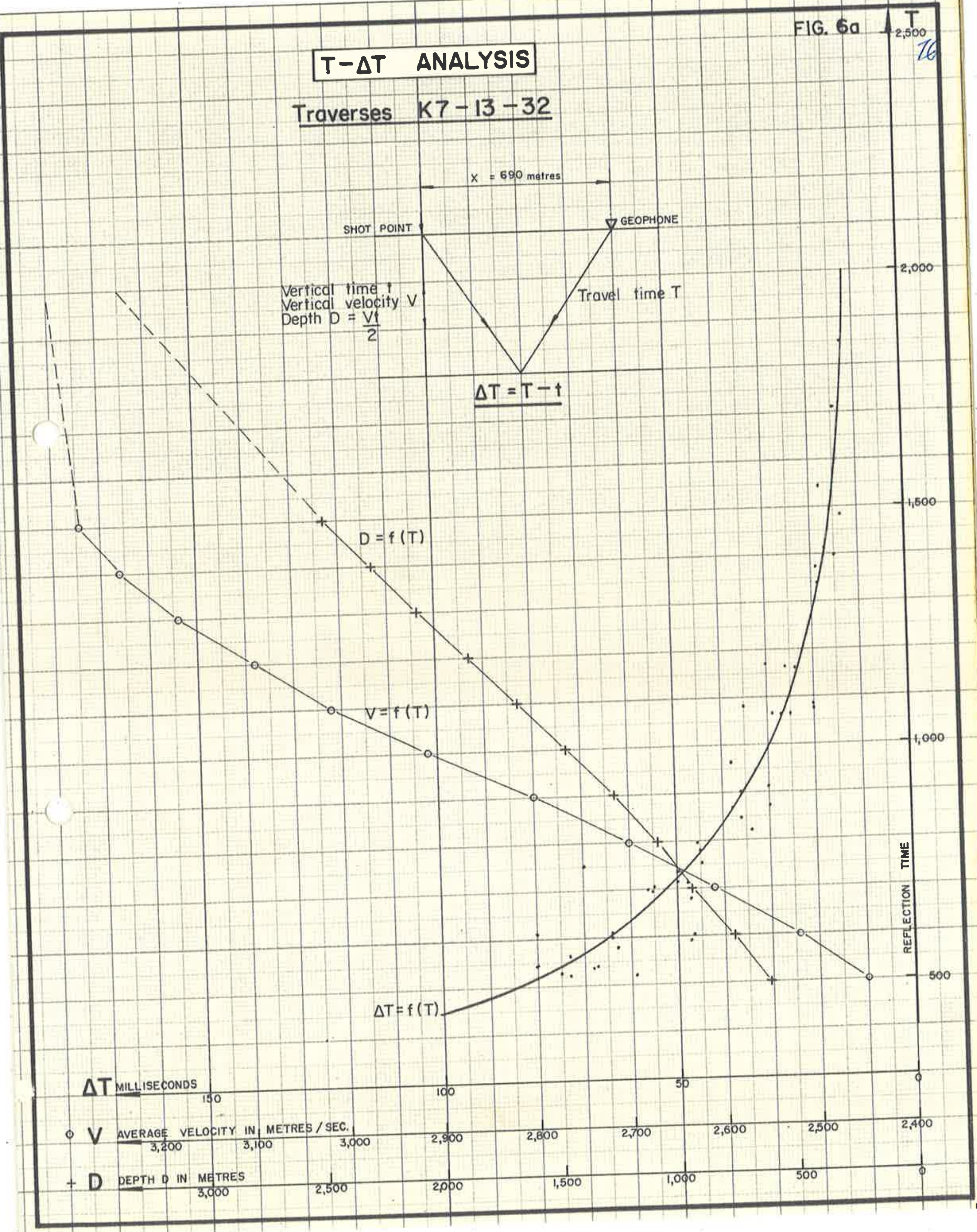


FIG. 6a
T-ΔT ANALYSIS
Traverses K7-13-32
X = 690 metres
SHOT POINT
GEOPHONE
Vertical time t
Vertical velocity V
Depth D = Vt/2
Travel time T
ΔT = T - t
D = f (T)
V = f (T)
ΔT = f (T)
T
REFLECTION TIME
2,500
2,000
1,500
1,000
500
0
ΔT MILLISECONDS
150
100
50
V AVERAGE VELOCITY IN METRES / SEC.
3,200
3,100
3,000
2,900
2,800
2,700
2,600
2,500
2,400
D DEPTH D IN METRES
3,000
2,500
2,000
1,500
1,000
500
0

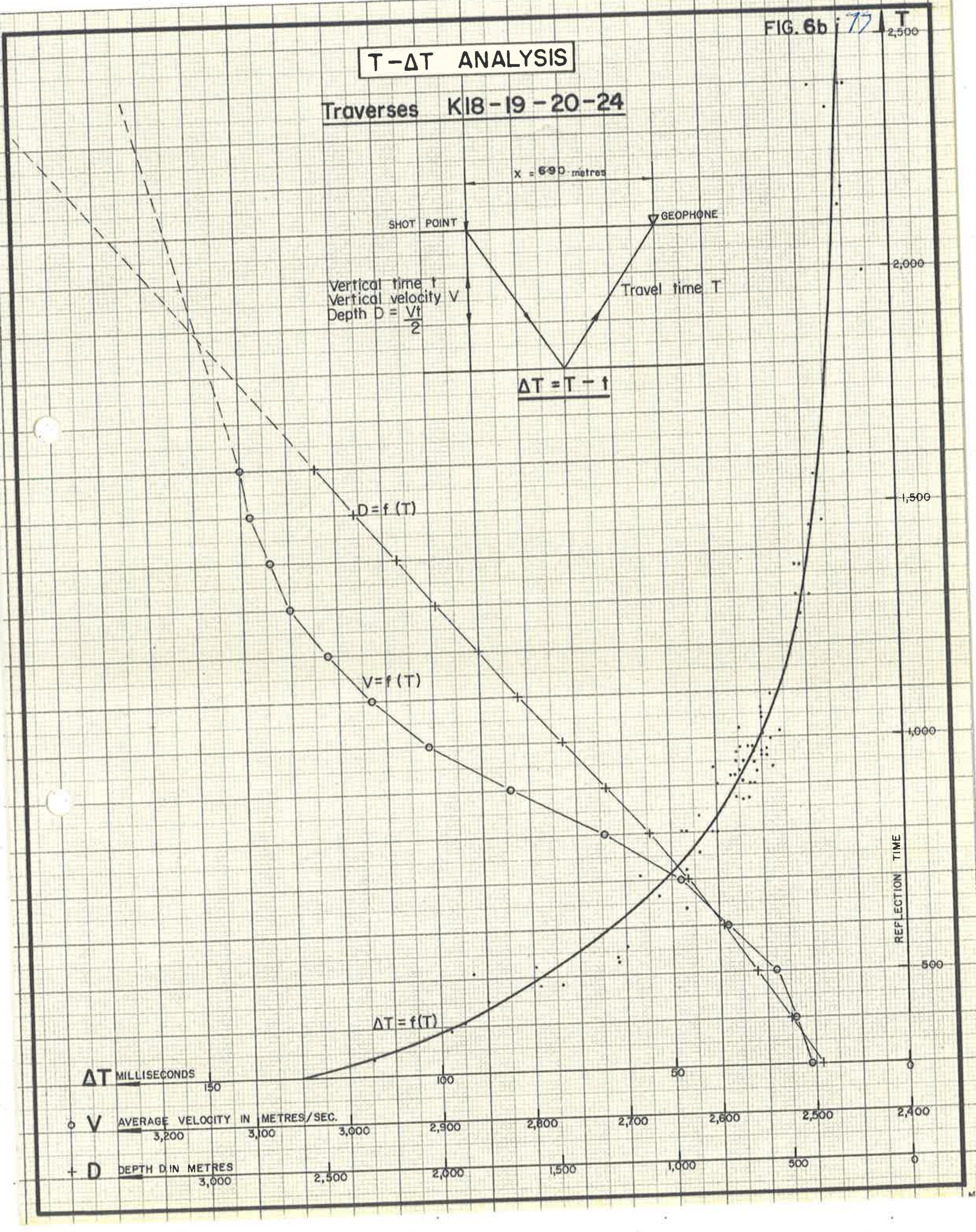
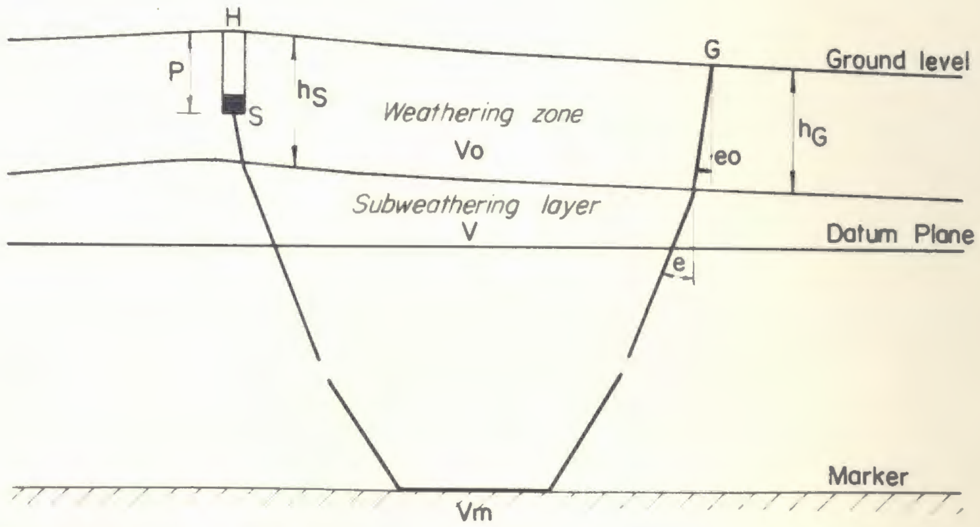


FIG. 6b
77
T-ΔT ANALYSIS
Traverses K18-19-20-24
X = 690 metres
SHOT POINT
GEOPHONE
Vertical time t
Vertical velocity V
Depth D = Vt/2
Travel time T
ΔT = T - t
D = f (T)
V = f (T)
ΔT = f(T)
ΔT MILLISECONDS
150
100
50
0
V AVERAGE VELOCITY IN METRES/SEC.
3,200
3,100
3,000
2,900
2,800
2,700
2,600
2,500
2,400
D DEPTH D IN METRES
3,000
2,500
2,000
1,500
1,000
500
0
T
2,500
2,000
1,500
1,000
500
REFLECTION TIME

FIG. 7.

REFRACTION CORRECTIONS



Vo = Weathering zone velocity

V = Elevation correction velocity

Vm = Marker velocity

Sin $e = \frac{V}{Vm}$ Sin $eo = \frac{Vo}{Vm}$

D.P. = Elevation Datum Plane

SHOT POINT CORRECTION

$Z_{S.P.}$ = S.P. Elevation

P = Maximum depth of the hole

h_S = Depth of the weathering zone beneath the S.P.

C_{SP} = S.P. elevation correction = $\frac{D.P.-(Z_{SP}-P)}{V/\cos e}$

CH = Horizontal correction if any

C_{WZ} = Weathering correction to the S.P. = $(h_S-P)\left(\frac{1}{V/\cos e}-\frac{1}{Vo/\cos eo}\right)$

$\Sigma c = C_{SP} + C_{WZ} + CT + CH$

GEOPHONE CORRECTION

Z_G = Geophone elevatton

h_G = Depth of the weathering zone beneath the geophone

E_C = Elevation correction = $\frac{D.P. - Z_G}{V/\cos e}$

C_{WZ} = Weathering zone correction to the geophone = $h_G\left(\frac{1}{V/\cos e}-\frac{1}{Vo/\cos eo}\right)$

STATIC CORRECTION

$\Sigma C = \Sigma c + C_{WZ} + Ec$

D.P.:

Vm:

V/cos e:

Vertical Velocities through WZ:

under WZ:

CORRECTIONS

SHOT POINT: CT, C_{sp}, CH, C_{wz}

Σ_e

INDEX

Observer:

Checked:

Computer:

EM

N	X	Z	EC	CW_z		$\Sigma C = EC+CW_z+\Sigma_e$	$\frac{X}{V}$	$\Sigma C-\frac{X}{V}$	Total Correction		CPO Corrections		N
1													1
2													2
3													3
4													4
5													5
6													6
7													7
8													8
9													9
10													10
11													11
12													12
13													13
14													14
15													15
16													16
17													17
18													18
19													19
20													20
21													21
22													22
23													23
24													24

W-S

COMPAGNIE GÉNÉRALE DE GÉOPHYSIQUE

2-REFLECTION DYNAMIC CORRECTIONS (Fig 6a-6b)

The move-out corrections were deduced from an analysis of the reflections carried out on each traverse or on groups of traverses . Results were comparable to those obtained during the 1963 survey Figures 6 a and 6 b show two of these T-Delta- T analyses. The C.G.G. " MTD Corrector " designed for corrections up to 200 milliseconds with any desired steps allowed a good reproduction of the move-out correction curves except for the eastern end of traverse K 22 (SP's 496 to 516) which was play-backed without move-out corrections. On this part of the traverse horizontal velocities of the order of 5,000 m/sec are recorded as first breaks .

3- REFLECTION INTERPRETATION DOCUMENTS

Magnetic tapes were processed at the camp. Play-back were corrected for static and move-out corrections and assembled in variable area cross-sections corresponding to ten shot points, with an 1/28-1/56 filter setting and medium AGC.

Horizontal scale : 1/8,000

Vertical scale : 7.5 inches for one second two-way time

4-REFRACTION SURFACE CORRECTIONS

The reference plane and the velocity parameters were the same as for reflection corrections .

Computation of refraction corrections is illustrated on Fig 7 which also presents the part of a refraction recording label dealing with the corrections.

5- REFRACTION INTERPRETATION DOCUMENTS

The documents included in the report are listed in Chapter V Part two.

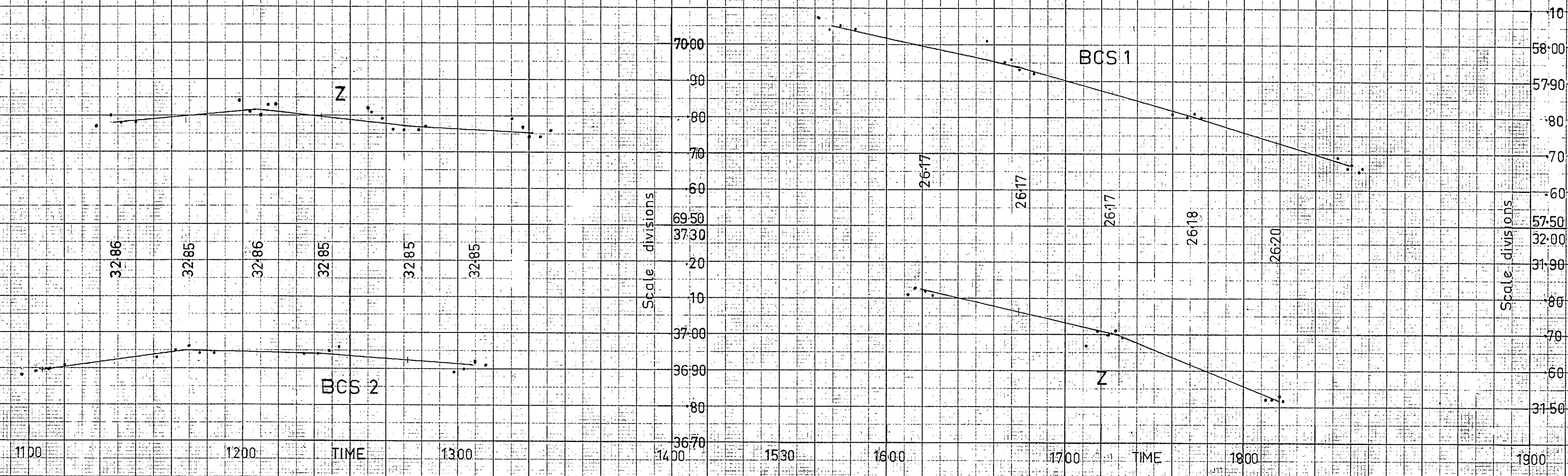
The files comprising the intercept sheets and the delay time computations are supplied to A.A.P.

FIG. 8 a

WORDEN No 41

INSTRUMENT CALIBRATION – BRISBANE

August 7th 1964



BCS 2 – Z = 32·85

Z – BCS 1 = 26·18

59·03 × K = 58·26 m/g

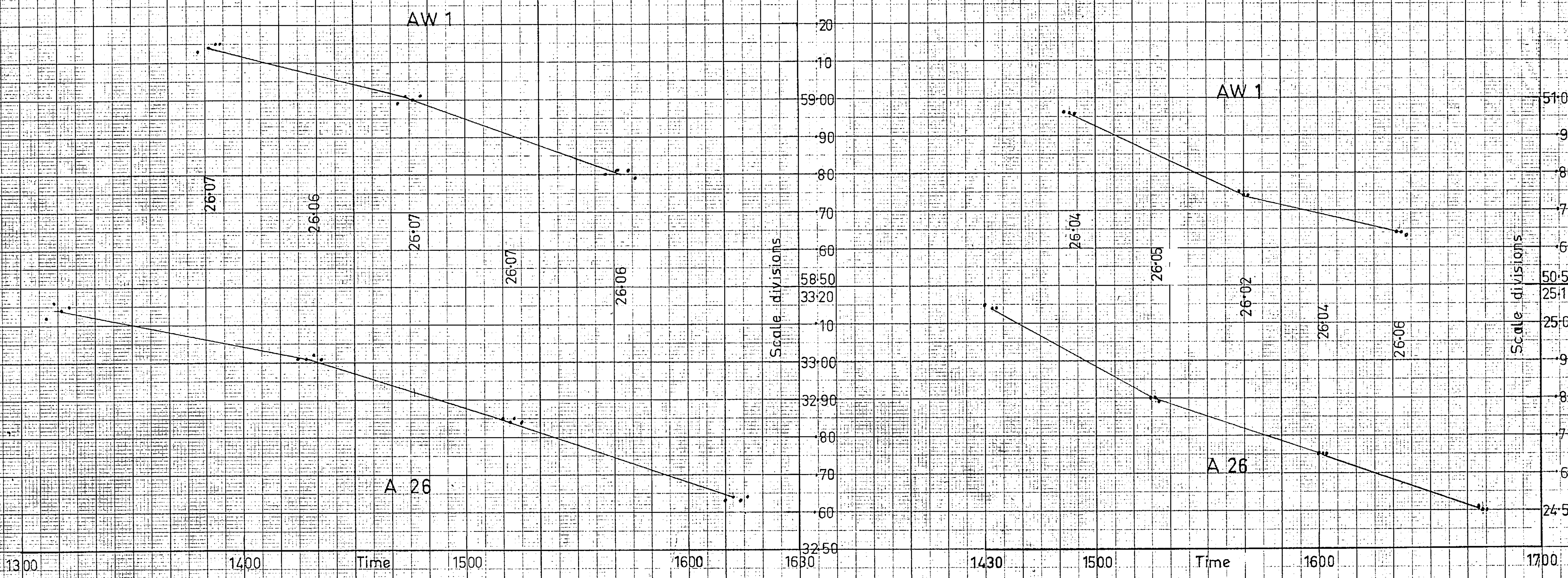
K = 0·986 (9)

FIG. 8b

WORDEN Nº 41

INSTRUMENT CALIBRATIONS – KULSHILL

August 26th 1964 | **October 11th 1964**



$26{\cdot}07 \times K = 25{\cdot}70$ m/g

$K = 0{\cdot}985(8)$

$26{\cdot}04 \times K = 25{\cdot}70$ m/g

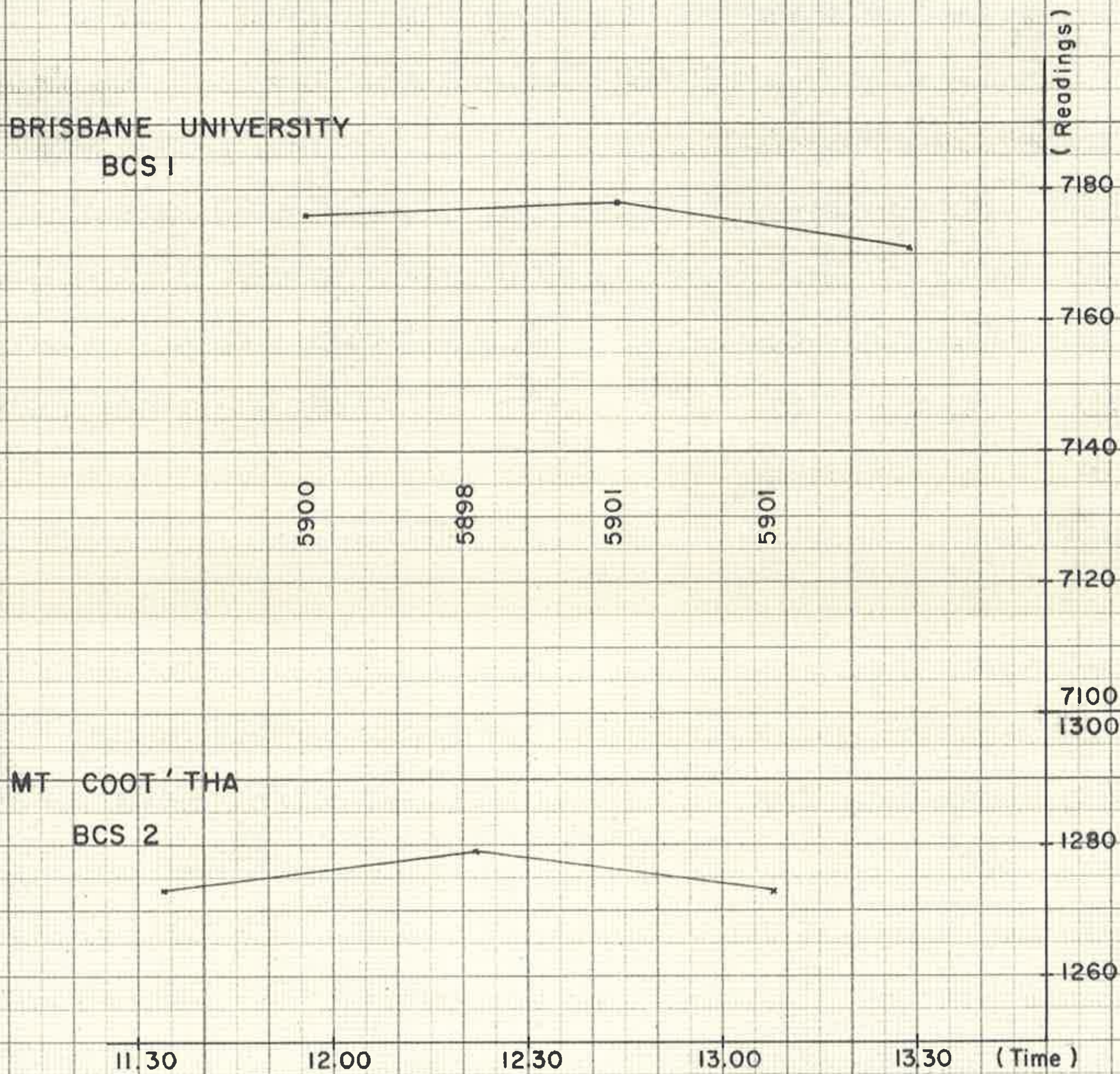
$K = 0{\cdot}986(9)$

FIG.8c

GRAVIMETER CALIBRATION

WORDEN PIONEER N°41.

4th December 1964



Observed gravity interval

BCS I - BCS 2 = 58·27 mgal (Nov. 1961)

58·26 mgal (Feb. 1963)

Calibration coefficient

$$K = \frac{58\cdot 26}{59\cdot 00} = 0\cdot 987 \text{ mgal / Div}$$

6-OFFSET SHOTS.

Two types of documents were used :

- The monitor records with the radio recorded time breaks,
- The play-backs of the magnetic tapes, corrected for static corrections.

The time break allowed an accurate assembly of the monitor records which was used as a guide for assembling the corrected play-backs .

7-GRAVITY

7-1. Calibration

The Worden No 41 gravitymeter already used in 1963 on the same permit was calibrated in Brisbane on the 7 th August 1964 by tying the bases of the Brisbane University and of Mount-Cootha (Fig 8 a).

As in 1963 the calibration coefficient K = 0.986 mgal/division was checked twice on the field on the 26 th August and 11 th October (Fig 8b). The calibration was checked again at Brisbane on December the 4 th (Fig 8c).

7-2. Values of G. Network of bases (Pl 22)

The present survey was tied to the 1963 " Pearce point" gravity survey .

Nine new bases were established (Pl 22) by making a series of ties to and fro a 1963 and the new base.

All misclosures are inferior or equal to 5 hundreds of a milligal .

7-3. Bouguer anomaly computation

Three density profiles were carried out at locations selected because of their topographic irregularity : SP 212 of traverse K12 (hill showing a difference of elevation of 35 metres for a 300 metres horizontal distance), SP 243 of traverse K 14 (hollow of 25 metres for a 220 metres horizontal distance) SP 710 of traverse K 26 (20 metres high hill for a horizontal distance of 220 metres) .

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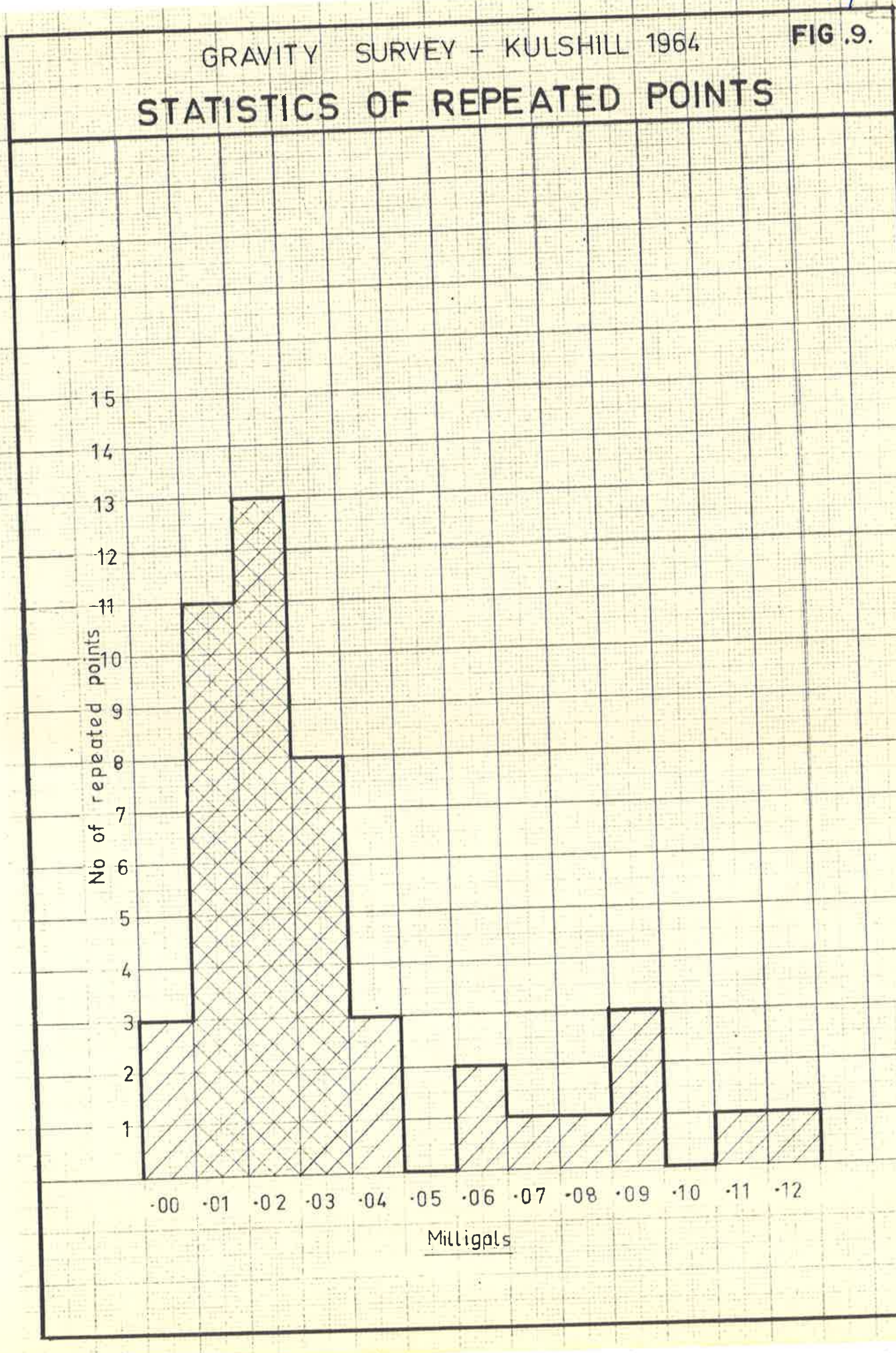
GRAVITY SURVEY - KULSHILL 1964
FIG. 9.
STATISTICS OF REPEATED POINTS
No of repeated points
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
·00
·01
·02
·03
·04
·05
·06
·07
·08
·09
·10
·11
·12
Milligals

None of them was very conclusive and a rock density of 2.1 was adopted for the elevation correction as in the previous 1963 survey. Go values were computed after tables giving the theoretical value of the gravity along the international ellipsoid .

A tidal correction and a gravitymeter drift correction were applied, the drift being considered a linear function of the time.

The values found for the Bouguer anomaly are plotted on the Bougüer anomaly map (Pl 23) .

7-4. Accuracy

All bases connections were made according to the usual requirements : less than 0.1 milligal discrepancy.

The repartition of discrepancies observed at the 47 repeated stations (9% of the total new stations) leads to a mean probable error of 0.01 to 0.03 milligals. (Fig 9).

LIST OF PERMANENT MARKERS

Line	Reflection S.P	Longitude X	Latitude Y	Elevation
K7	312 = 1 PP7	216,586	2,893,865	8.68
K12	201 = 60 PP8	203,370	2,909,925	52.63
	210 = 334 K16	208,539	2,905,987	65.93
	220	214,346	2,902,551	14.57
	230	219,280	2,897,265	30.88
	344	224,041	2,894,029	8.77
K1[illegible]	262= 107 PP8	198,308	2,901,759	36.38
K1[illegible]	236= 30 PP7	202,439	2,903,901	46.46
	240	205,065	2,904,019	60.99
	250	211,420	2,904,334	41.45
	261	219,973	2,905.118	36.14
K15	311	190,516	2,904,670	14.24
	300= 103 PP8	197,022	2,899,729	22.61
K16	330	208,676	2,902.971	48.29
K17	354=641 K31	204,601	2,896,813	10.87
	346	204,214	2,902.578	52.82
K18	416	210,959	2,925,098	14.67
	420	213,714	2,924,296	21.07
	425= 355 K19	217,182	2,923,338	23.51
	430	220.548	2,922,097	22.91
	440	227,055	2,919.495	82.76
	449	233,093	2,217.297	20.96
K1[illegible]	360	218,911	2,926.454	11.49
	370	222,100	2,932,774	46.81
	377= 406 K20	224,271	2,937,210	45.27
	380	225,243	2,939,128	34.34
	338	227,703	2,944,061	16.67
K20	390	214,836	2,942,340	10.92
	400	220,203	2,938,589	28.39
	410	226,994	2,936,287	47.49
	415	230,395	2,935,164	9.20
K21	689	214,974	2,903,154	27.79
	697	213,906	2,913.797	40.30
	706	212,166	2,919.944	11.46
K22	460	216,100	2,916.929	35.27
	470	222,897	2,914.659	82.15
	490	235,987	2,910,099	56.88
	500	242,769	2,907,586	20.80

Line	Reflection S. P	Longitude X	Latitude Y	Elevation
	510	249.513	2,905,090	17.02
	514	252,200	2,904,091	20.11
	515	252,871	2,903,841	25.53
	590	216.316	2,989.197	27.64
	580	220.026	2,904.405	33.55
	570	223.624	2,910.654	94.24
	560	227.247	2,916,595	56.77
K23	550	230.982	2,922.753	29.42
	544	233.290	2,926.521	17.51
K24	516	216.077	2,933,233	11.40
	520	218.674	2,932,004	15.02
	530	225.321	2,929.345	60.47
	543	234.207	2,926.213	11.28
K27	624	204.519	2,912.401	54.01
	611	212.084	2,906.921	28.69
	600	218,700	2,902.252	52.10
K28	650	201,925	2,903.135	39.69
	660	206,230	2,908.871	74.08
K29	677	201,541	2,907.631	29.90
	668	206,949	2,904.067	102.62
K33	763	190.478	2,900.321	15.84
	759	192.046	2,902.657	15.30
	749= 43 PP7	196.218	2,908.508	33.88
	746	197.511	2,910.225	13.82

Universal Transverse Mercator projection system

Australian Belt Zone 4.

Co-Ordinates calculated in the metric system are not compensated

Elevations in metres above mean sea level , are compensated