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BRINGING FORWARD DISCOVERY
IN AUSTRALIA'S NORTHERN TERRITORY

AUSTRALIAN AQUITAINE PETROLEUM
PTY. LTD.

OAKES CREEK

SEISMIC and GRAVITY SURVEY

AUGUST - OCTOBER, 1967

OPZ

OPEN FILE

PR67/19 A

COMPAGNIE GENERALE DE GEOPHYSIQUE

COMPAGNIE GÉNÉRALE DE GÉOPHYSIQUE

AUSTRALIAN AQUITAINE PETROLEUM PTY. LTD.

OAKES CREEK SEISMIC AND GRAVITY SURVEY

August - October 1967.

By

COMPAGNIE GENERALE DE GEOPHYSIQUE

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ABSTRACT

A seismic reflection-refraction and gravity survey was carried out between the 1st. of August and 14th. of October 1967 by COMPAGNIE GENERALE DE GEOPHYSIQUE on behalf of AUSTRALIAN AQUITAINE PETROLEUM PTY. LTD. in Oil Permit 2 in the Northern Territory.

One refraction traverse and eleven reflection lines were recorded. Gravity readings were taken at every fourth reflection shot point, at every second refraction trace and on three supplementary gravity lines.

Average velocities are increasing from 3000 m/s under W-Z to 4000 m/s on the basement.

Horizontal velocities of refraction markers are 4050, 4500 and 6000 m/s.

While the basement is dipping northwards, the layers above are undulated with a high axis oriented north-south. An east-west faulted zone lies in the middle of the recorded area which makes refraction difficult to follow.

A structure can be suggested north of this faulted zone.

FOREWORD

A seismic and gravity survey, the subject of the present report, was carried out by COMPAGNIE GENERALE DE GEOPHYSIQUE on behalf of AUSTRALIAN AQUITAINE PETROLEUM PTY. LTD. in OIL PERMIT 2 in the Northern Territory.

This survey was called the OAKES CREEK SURVEY and followed several previous seismic and gravity surveys in the same general area. Seismic reflection and refraction and gravity methods were employed.

Two bulldozers were employed opening access roads and clearing seismic lines and shot point patterns.

Drilling started on July, 31st. 1967. When the drilling operations ended on October 12th, 3,414 holes totalling 190,300 feet had been drilled.

Seismic operations were carried out between August 1st. and October 14th. 934 six-fold coverage spreads and 12 refraction bases were recorded. Gravity readings started on August 4th. and finished on October 8th.

B. DUVERGÉ headed the party which was supervised from Brisbane and in Oakes Creek area by R. Weber for A. A. P. and R. Hilliker for C. G. G.

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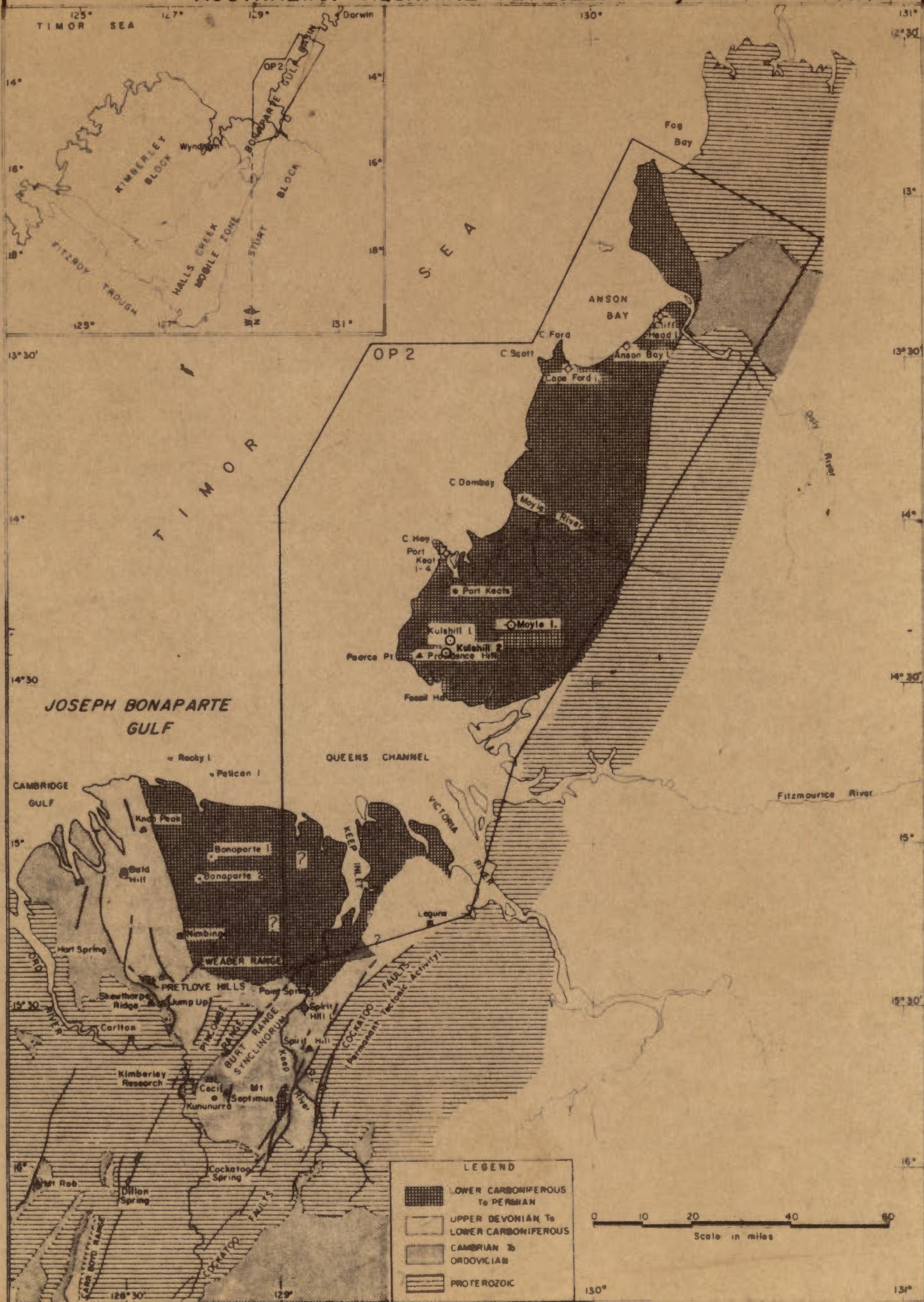
AUSTRALIAN AQUITAINE PETROLEUM Pty. Ltd. FIG. I



AUSTRALIAN AQUITAINE PETROLEUM Pty Ltd.

OP 2

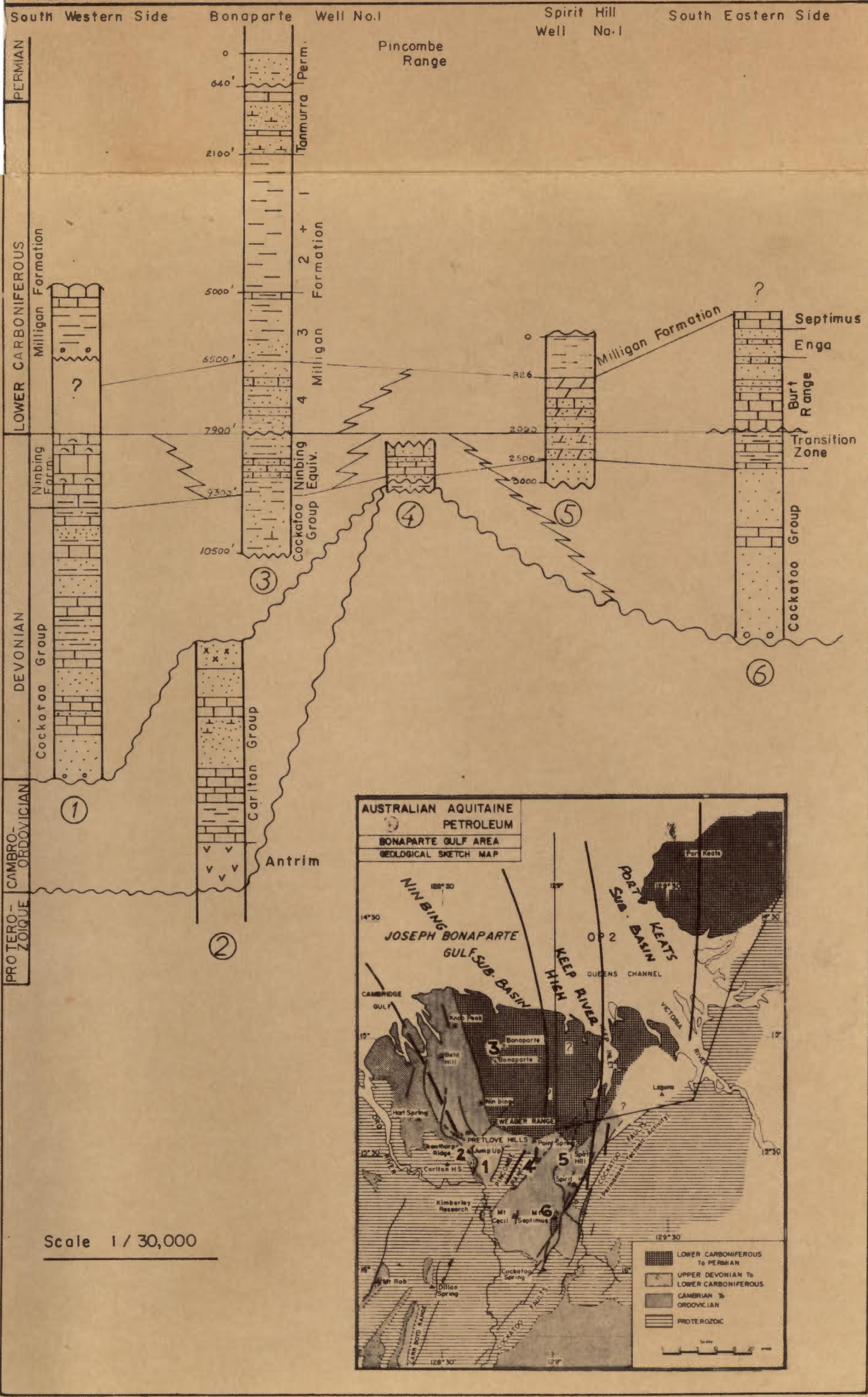
FIG. 2

OAKES CREEK SEISMIC & GRAVITY SURVEY 1967

Lithostratigraphic Columns & Correlation

GEOLOGY

Date :- December 1967



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CHAPTER I

GEOLOGICAL AND GEOPHYSICAL DATA
(Supplied by A. A. P.)

1. GEOLOGICAL DATA

The study is located in the Bonaparte Gulf Basin on the coastal region of North West Australia, lying in the Northern Territory.

Outcropping rock units are mainly Paleozoic with a small veneer of Mesozoic.

Broadly speaking, the Paleozoic Bonaparte Gulf Basin is bounded by two Proterozoic blocks, the Kimberley block on the west and the Victoria River block on the east. (See Fig. 1). The onshore part of the Bonaparte Gulf Basin is divided into two areas by the Queen's Channel.

The Keep River area, which constitutes the location of this survey, is situated in the southern area where the main outcrops range from Lower Cambrian to Permian as follows :

Age	Maximum Thickness	Lithology
Lower Permian	0 to 3000'	Glacial, sandy and microconglomeratic shales deposits and sandstones at the bottom.
	Unconformity	
Lower Carboniferous	4000 to 6000'	Sandstone, siltstone, shale and dolomite
	Unconformity	
Upper Devonian	6000'	Reef limestones and dolomite sandstones and conglomerate
	Unconformity	

Continued......

Age	Maximum Thickness	Lithology
Middle Cambrian to Lower Ordovicien	4200'	Glauconite sandstone, sandstone dolomite and shale
	Unconformity	
Lower Cambrian	150 to 2000'	Basalt tuff, breccia and conglomerate
	Unconformity	
Proterozoic	?	Quartzite, siltstone, shale and volcanic

The outcropping sedimentary sequences of the Cambrian - Lower Ordovicien and Upper Devonian - Lower Carboniferous are of the same sort, and were deposited in a shallow sea : sandstone in response to uplift of the Pre-Cambrian source area in the south, and limestone by biogenous deposition at the end of periods of uplift.

A different style of deposition started with the Lower Permian, a fluvio-deltaic conglomeratic quartz sandstone succeeded by glacial sediments.

In broad structural terms, folds are virtually unknown in the Bonaparte Gulf Basin, and the main movements have been effected by step and block-faulting, tilting and epeirogeny.

Numerous trends of faulting were recognised and tentative attempts were made to classify their succession.

- The first and most important is due to the effect of the Halls - Creek mobile belt which has a north and northeast strike.

- The second trend of faulting is northwest and is clearly visible in the Pretlove Hills affecting the Cambro-Ordovicien.
- The third is a reactivation of the Halls Creek mobile belt during the Lower Carboniferous, and is defined by the Cockatoo fault.
- The fourth and probably one of the last, is a reactivation of the northwest trend visible in the south of Weaber Range and the possible lineation of the shore line.

According to all these above considerations and interpretation of previous seismic, gravity and airmag surveys (in conjunction with sedimentologic data) it appears that the onshore part of the Bonaparte Gulf Basin might be subdivided into two Paleozoic Ante-Permian sub-basins. The Port Keats and Ningbing sub-basins are separated by a high zone which, in this area, would be located westward of the Keep river, on the extension of the Pincombe Range. These sub-basins should be filled with fine clastic sediments like those found in Kulshill 1 and Bonaparte 1, while the high zone would show coarse clastic and carbonated sediments.

Lithostratigraphic columns and correlations of the Bonaparte Gulf area in enclosure show this variation of the lithology and some important changes between the two flanks of the basin.

2. GEOPHYSICAL DATA

2.1 PREVIOUS GEOPHYSICAL WORK

Previous gravity work consists of lines surveyed by a MINAD crew in 1965 and 1957 and a B.M.R. crew in 1956. The results of these surveys are summarized in the B. M. R. published gravity maps and a MINAD report "Regional Gravity Survey of the Bonaparte Gulf Basin" 1958. The "Legune Seismic and Gravity Survey" was carried out by PETTY Party 30 during their 1964 campaign for A. A. P.

Seismic Surveys on O. P. 2.

In 1962, seismic reflection and refraction work was carried out by G. S. I. under the supervision of MINAD for Associated Australian Oilfields. In 1964, seismic reflection and refraction work was conducted by Petty Geophysical Engineering Company for A. A. P. In addition, a marine seismic survey was conducted in 1964 by Western Geophysical in the Queen's Channel for A. A. P.

In 1965, Petty Geophysical Engineering Company carried out the Skull Creek Seismic Survey on behalf of A. A. P. in an area where geological and geophysical data indicated that the PINCOMBE RANGE possibly extended northward along the western border of the permit.

In 1966, on behalf of A. A. P., Compagnie Générale de Géophysique carried out a semi-detailed programme of marine seismic (FLEXOTIR) which detailed the high area located in the Queen's Channel and controlled several faulted structures west of Pearce Point.

Velocity surveys were also made in the Kulshill No. 1 and No. 2 wells.

Seismic Surveys in Close Proximity to the Oakes Creek Survey

In 1962, General Geophysical Company Ltd. carried out a seismic survey on the Spirit Hill area (formerly O. P. 3), on behalf of Oil Development N. L. A few lines of this survey were shot close to and on the southern limit of O. P. 2.

Westward, on P. E. 127H, the following seismic surveys should be mentioned:

1962	CGG	Carlton Basin Seismic Survey (Oil Development)
1963	UNITED	Nimbing-Burt Range Seismic Survey (Alliance)
1964	PETTY	Surprise Creek Seismic Survey (Alliance)
1965	PETTY	Tanmura Seismic Survey (Anacapa)
1964	Well Velocity Survey of Bonaparte No. 1 well.	

2.2 MAIN RESULTS IN THE VICINITY OF THE OAKES CREEK SURVEY AREA

An evaluation of the geological data and the scattered geophysical results indicates that the Burt Range syncline (outcropping in the south) may extend to the north in the area surveyed.

The Spirit Hill No. 1 Well appears to be situated in this sub-basin. Further north the only indication available for this purpose appears to be the possible syncline axis delineated by the Spirit Hill Seismic Survey near the limit between O. P. 2 and former O. P. 3 (results quoted as poor)

Two hypothesis can be stated, concerning a possible high axis, trending to the north.

- The Pincombe Range high may extend northward along the western border of the permit. The purpose of the Skull Creek Seismic Survey was to check this extension of the Pincombe Range trend. Line SC 1, shows an undeniable high, but its relation to the southern faulted zone could not be elucidated. The results on SC 2 seemed to indicate a slight synclinal feature, but results were poor and SC 3 line gave no results at all.

- The second hypothesis correlates the high anomaly located on SC 1 with the questionable high area shown on traverses ND and M of Spirit Hill Survey and pictures a north-south anticlinal trend on the western bank of the Keep River.

The Bouguer anomaly map, though obtained from only a few, wide spread readings, indicates a north-south faulted zone (local incurvation of the isogal curves) which may be related to the faulted area shown on line L 10, (SP 127-129). This faulting system may possibly complicate the assumed northern extension of the Burt Range syncline axis and its relation to the eastern flank of the high shown on SC 1 East (downthrown to the west). The previous geophysical data is insufficient to give an understanding of this complex area, where seismic results are difficult to obtain.

The over-all seismic results show that the sediments are thickening from south to north, where the quality of the seismic results improve.

2.3 QUALITY OF SEISMIC RESULTS AND TECHNIQUES USED IN THE PREVIOUS SURVEYS

The previous seismic works carried out in the vicinity of the Oakes Creek Survey area, show that reliable seismic reflection results are difficult to obtain. Two major unfavourable factors seem to exist. In some areas there is an obvious decay of reflected energy (SC 3) due perhaps to a lack of good velocity contrast in the sedimentary series, which prevents the emergence of the reflected signal above the background noise on the record. In other areas (SC 1) strong multiple reflections seem to occur.

The experience of the Skull Creek Survey indicated that multiple coverage would be the best tool to improve seismic results. Compared with single coverage multiple coverage gave improved reflections but gives little attenuation of probable multiples. Consequently, SC 1 was reshot using a split spread layout and six-fold stacking techniques for data improvement and for random noise cancellation.

Multiple reflection attenuation requires long spread configuration which gives better results with current CDP processing methods. However, valuable information may deteriorate within the first 400 milliseconds of the record if one uses long spreads and large offsets.

Previous refraction work in the Legune/Keep River area was only more or less efficient. However, results were encouraging enough to suggest that with further work (using more convenient equipment than previously used), it might be possible to calculate the depth of the very consolidated (possibly basement) 6,000 m/s marker present. In addition much better knowledge of the structural attitude of sedimentary layers might be obtained.

As no well has been drilled in the survey area, correlation of the markers with geological formations is questionable.

In the Legune area correlation with geological outcrops shows that a 4,600 - 4,800 m/s marker might correspond to a sandstone formation of any age from Proterozoic to Permian.

Whatever the age of the 5,800 - 6,000 m/s marker, it represents highly consolidated rocks which could be of Cambrian and/or Proterozoic age (ANTRIM basalts or crystalline basement).

CHAPTER II

PURPOSE OF THE SURVEY AND PROGRAMME

(Information supplied by A. A. P.)

1. PURPOSE OF SURVEY

The main objective of the OAKES CREEK Seismic and Gravity Survey was to define the structural trend shown on the line SC 1 (SKULL CREEK Survey, 1965) by :

- Locating the actual position of the anticline axis and its structural top.
- Looking for its structural closure, to the southeast, north and west. (The northern closure, suggested by the general dip toward the north of the basin as confirmed by marine seismic surveys, might not be fully confirmed onshore).
- Studying the north-south faulting system which might complicate the eastern closure of the aforesaid anomaly.
- Listing all possible reflectors or refraction markers and their estimated depth to enable the outlining of a drilling programme.

Gravity readings would complete the previous widely spaced measurements and would add geophysical data to assist in the solution of the structural problem.

2. PROGRAMME

The initial programme was partly theoretical in that the geophysical method had yet to be chosen. Also the location of the detail lines depended on the results of the first lines shot. Reflection line OC 1 was to be shot first and would be followed by refraction line OCR 1.

This northwest-southeast refraction line was intended to give an idea of the basement depth and information on the southern extension of the high axis shown on reflection line SC 1. The line crosses the possible north south faulted system mentioned above and ends in an area where shallow basement was expected (cf. Line L 10 and Line KRRA).

Unfortunately OCR 1 crosses the Keep River and a gap was expected. Moreover, it was foreseen that the offset shot points towards the north west end of the line would be limited by topographical conditions, this area being subject to flooding at high tide.

Two more traverses (OCR 2 and OCR 3) were planned. Line OCR 2 aimed at the same objectives as Line OCR 1. Line OCR 3 would run along the axis (if any) of the high anomaly shown on line SC 1 and would investigate a possible southern closure.

The shooting diagram for all the refraction lines was to be arranged to order to allow Gardner-Layat exploitation of two markers, one in the 4, 500 m/s group (15, 000 ft/sec.) and one in the 5, 800 m/s or 6, 000 m/s group (20, 000 ft/sec.) if possible. Lines OCR 2 and OCR 3 were later cancelled.

The initial reflection programme consisted of five short lines which it was hoped would define the high anomaly shown on line SC 1. Lines OC 1, OC 2 and OC 4 were planned to determine the structure axis, while OC 3 and OC 5 were planned as tie lines.

Previous seismic work carreid out in the area showed that seismic results could be improved using multiple coverage techniques and therefore all lines were planned to be shot and processed using a six-fold stacking. The first line OC 1 (the closest to the line SC 1) would be recorded using a compromise between split spread and off-end spread. The first configuration is better for random noise cancellation and shallow events while the second is better for multiple cancellation.

It was expected that it would not be possible to select a suitable offset for multiple reflection attenuation until the thickness of the sedimentary section had been approximated and until the true velocity function (associated with these sediments) had been measured.

The Gravity programme set out that readings be taken on surveyed points with the following spacing :

- On refraction lines : every second trace and every offset shot point.
- On reflection lines : every fourth shot point in 6 fold coverage.
- On access roads (if surveyed).

Base stations could be spaced up to eight kilometres apart. However stations were to be close enough to permit a return to the base every two hours.

The gravity work conducted by Petty Geophysical Company during the Legune Survey was based on the observed value to Mines Administration gravity station No. 317 (A. A. P. No. S67) given as 978. 41726 gal.

Measurements made during the Oakes Creek survey were to be tied to every nearby base of the Legune Survey.

Density to be used for the computation was 2. 0 gal/cm3.

CHAPTER III

TECHNIQUE AND OPERATIONS

1. TECHNIQUES USED:

1.1 REFLECTION

All the lines were shot using six fold coverage. Sections of 15 pair seismic reflection cable were connected to give a total spread length of 1,440 metres (24 traces, 60 metres apart).

Geophones patterns consisted of 36 HS-J reflection geophones (20 c.p.s) laid in three lines of 12, parallel to the traverse and 10 metres apart. The first line of geophones was laid along the edge of the line cut by the bulldozer. On each line the geophones were 5 metres apart.

Several shot patterns were tried (see experiments). However the pattern used most consisted of 3 holes in line, 10 metres apart, drilled 60 feet deep. The holes were drilled on the seismic line itself. Shot points were spaced 120 metres (2 traces) apart. The charge of explosives used ranged from 45 lbs. to 240 lbs per shot point (not including experiments).

On line OC 1 shot points were located between traces four and five and a shooting cable connected the shot point with the recording truck. After each shot two traces were disconnected at one end of the spread (actually traces 1 and 2) and two new traces were connected at the other end, so that the new spread was ready for the next shot. The first break of trace 4 was considered as up-hole time. This process was repeated for the whole reflection line.

For lines OC 2 to OC 11 shot points were located 240 metres from trace 24 outside the spread. Time break was transmitted by radio equipment. Up-hole time was provided by a geophone located near the hole.

After each shot two traces were disconnected at the end of the spread nearest the shot point (actually traces 24 and 23) and two new traces were connected to the other end. The new shot point was located 240 metres from the new trace 24 (trace 22 of the former spread).

This process was repeated for the whole line.

1.2 REFRACTION

Refraction probes and shots were recorded in order to enable the Gardner-Layat method of interpretation to be used.

Refraction cable sections, 800 feet long, were connected to provide a total spread length of 2,460 metres (12 traces, 240 metres apart).

Records were made using two spreads or "bases" of twelve traces each, giving a total of twenty-four traces per record.

At each cable connection twelve LI B geophones, 4.5 c.p.s., were laid out in two symmetrical lines 15 m. apart consisting of six geophones, 10 m. apart perpendicular to the line.

The refraction shots were recorded on 24 traces from different shot points on either side of the spreads. After completion of the recording on the two initial spreads (bases one and two), the twelve traces of the first "base" were shifted forward and recording was resumed on bases two and three. This process was repeated for the whole refraction line.

The shot points were drilled each six or twelve traces and consisted of several holes on a line perpendicular to the traverse. Charge size varied, depending on the shooting distance and on the noise level.

1.3 GRAVITY

Gravity readings were made each fourth shot point on reflection lines and every other trace (even number) on refraction line, OCR 1.

Moreover, readings were also made along the southern extension of line OC 3 to where it reaches the Western Australia border and along the planned refraction line OCR 2 already cut by bulldozer.

Readings were also made on the offset shot points of the refraction line, OCR 1.

Base stations were established.

2. OPERATIONS

2.1 NATURAL CONDITIONS

The weather was mostly fine throughout the survey becoming hot and wet from September.

2.2 ACCESSIBILITY

From Kununurra the Legune Station Road could be used by all heavy vehicles. At the Keep River Yard, 40 miles from Kununurra, a track lead to the previous Petty camp located 20 miles to the north. Oakes Creek crossing had to be smoothed to allow the passage of heavy trucks.

All seismic lines and shot point patterns were cleared by the bulldozers and travelling along the lines was possible despite very sandy surface.

Salt pans and mud flats except when dry, were impossible to cross, even using light vehicles.

The seismic crew moved in on August 1st. when the cutting of OC 1 and OCR 1 had been completed.

The Keep and Little Keep Rivers produced some crossing problem. For the Keep an upstream detour of approximately 40 miles to the Keep Yards Crossing was necessary. For the Little Keep a four mile detour upstream was cut to a point where a permanent crossing could be made.

The area was bounded to the North by semi-tidal salt flats and to the East by mud flats along the western bank of the Keep River. The only lines that crossed the Keep River were OCR 1 and the proposed OCR 2.

Travelling conditions were generally unpleasant throughout the area due to the rapid formation of "bull dust" on most tracks.

2.3 CAMP

One camp was used for the whole survey. The location of this camp (see Fig. 19 Schematic Location Map) was the same as used by Petty during the Skull Creek Survey. Travelling time between the camp and lines never exceeded one hour except for work on the east bank of the Keep River or the western end of OCR 1.

2.4 LOGISTICS

Food

Fresh and packaged food was brought into the camp by C. G. G. vehicle as often as necessary from Kununurra where a good selection was available.

Water Supply

Fresh water for cooking and drinking was pumped from the Keep River at a point just upstream from the Keep Crossing.

Drilling and washing water was available from a hole drilled at the camp location (water level at 30' deep).

Fuel and Lubricants

These were supplied by the Shell depot in Kununurra and were transported to the camp location by a local carrier.

Dynamite and Detonators

Explosives were supplied by Imperial Chemical Industries of Australia and New Zealand Ltd. in Perth. They were transported into the camp by a hired carrier.

Geophex Polar, 10 lb. cartridges, size 2' x 3" and Geophex Anzite blue, 5 lb. cartridges, size 2' x $2\frac{1}{2}$" were used in conjunction with Nobel Electric detonators, 30' and 60' wires.

2.5 COMMUNICATIONS

Communications were good through Kununurra for the mail and air transport services. Travelling between Kununurra and the camp site (60 miles) was fair.

Several radio schedules per day for telegrams and medical advice were arranged with the Flying Doctor Service based at Wyndham.

Daily contract with A. A. P. in Brisbane was maintained using an SSB radio-telephone system supplied by A. A. P.

2.6 BULLDOZING

Two bulldozers (a D6C and D7) were used at the beginning of the survey, but later when it appeared that one would cope the D7 was released.

For reflection, lines were dozed two blades wide with no special provision for shot points. For refraction, single width lines were used. Refraction shot points consisted of a single cut at right angles to the main line and about 60 yards either side of it.

2.7 SURVEYING

The area in general is mildly undulating with light to medium coverage of eucalyptus and acacia. In the north and northwest semi-tidal salt flats were encountered.

Several seismic surveys had been conducted previously in the area using different datums. During 1966 and 1967, A. A. P. took steps to correct the condition and established two bench marks to which future surveys could be connected. These points were called A. A. P. B. M. 1 and A. A. P. B. M. 2. A survey in 1966 tied these bench marks to the two National Mapping Geodetic stations, Weaber and Wicklow. In 1967, this connection was established more precisely and a further connection was made to a Western Australia - Northern Territory border marker M 60 N. This mark was found near the southern end of OC 3 extension during the present survey and has since been adopted as the topographical datum for the survey. Grid values on the Universal Transverse Mercator Projection using the Australian Geodetic Datum have been calculated.

M 60 N is defined as:-

UTM Zone	Latitude (S)	Longitude (E)	Easting (Metres)	Northing (Metres)
52	15°20'00. 81"	128°59'56. 98"	499, 909. 95	8, 304, 774. 58
Elevation :	Top of concrete pillar 50. 90 metres (A. M. S. L.)			

Shot point and trace positions were laid out with a steel cable and were marked with wire 'flags' labled with coloured plastic tape. Shot point positions were later confirmed by stadia traverse using a WILD TO, Compass Theodolite. Where possible, all traverses were closed to form loops which were later adjusted to give the values used for the final location map. All coordinates and elevations were calculated in metres.

Permanent markers (11ft. lengths of 2 in. diameter galvanised iron pipe driven 3ft. into the ground) were placed near line intersections at the nearest adjacent shot point on each line. On longer lines, additonal permanent markers were placed at convenient points between intersections. A list of these permanent markers and Petty markers encountered during the survey and their coordinates and elevations are given in Appendix V.

The magnetic declination values used during the survey varied from $+3^{\circ}25'$ in the west to $+3^{\circ}28'$ in the east. These values were based on sun observations made to A. A. P. B. M. No. 1.

Maximum loop misclosures were:

36.9m in X

19.3m in Y

0.69m in Z

The following reference documents were used:

- Aerial Photomosaics (scale 1:50,000)
- Aerial Photographs (approximate scale 1:80,000)
- Australian National Mapping Auvergne (scale a:250,000)
- A. A. P. location map (scale 1:100,000)

The following documents are included in this report:

- Location Map (scale 1:50,000) Pl. 33
- Location Map (scale 1:100,000) Pl. 34
- Misclosure Maps X, Y and Z. Pl. 35, 36, 37.

2.8 DRILLING

The crew started with two conventional Mayhew 1000 rotary drills adapted for air or water drilling.

It soon appeared that 2 day shifts and even 2 day shifts plus one night shift would not allow a full utilization of the recording crew; therefore an extra rig was provided on September 4th. and a second extra rig on September 14th.

The drillers worked 6 days a week on day shift to allow technical maintenance for the rigs on the 7th. day. Most drilling was done by air. Water drilling was used only when thick clay layers were encountered.

Production was fair. Sand, shales, clay, sandstone and sometimes gravel were encountered. Shooting was not possible (even using pre-loading) in the areas neighbouring the mud flats as the holes caved in immediately after being drilled, the mud underlying an indurated crust.

The drilling rate was slowed down where gravel layers were encountered, particularly in the area of OC10/OC11 crossing. Cuttings were collected from the bottom of the shot holes where hard formations were encountered for the Bureau of Mineral Resources and A. A. P. 's Geological Laboratory.

CHAPTER IV

COMPUTATION RESULTS AND INTERPRETATION

1. REFRACTION

In order to cope with the uncertainty of the reflection results a refraction programme was established despite the unfavourable conditions existing on O. P. 2.

Actually the strong dips on the eastern edge of the basin made the use of the Gardner-Layat method hopeless outside its theoretical limits.

Access conditions did not allow a seismic line long enough for a good comprehension of the records and therefore an accurate interpretation.

Moreover, line OCR1, already short, crossed the Keep River and only one common trace tied both sides of the river providing rather poor connection.

In addition the whole area is well timbered and windy conditions provoked a high level of noise compelling the recording crew to work at night when the wind had dropped.

It is necessary to take into consideration these conditions before studying the refraction results and comparing them with the reflection cross-sections.

Refraction work provided valuable information concerning the basement in the basin (information very poorly provided by reflection).

Although structural movements of ten milliseconds can be hardly picked on refraction markers, it is however noticeable that the reflection cross-sections provided us information about dip rather than very accurate values for time-contour maps.

The field parameters and the quality of the records are indicated on the statistical diagram (see Pl. 25). The line was recorded from south-east to the north-west.

Despite the large number of shots interpretation was difficult.

As a result of the very distinct dip of the deepest marker - called M1 - south-east of the Keep River, the character of the arrivals and their apparent velocities are different for direct and reverse shots: about 5,000 m/s. for direct shots and about 8,000 m/s. for reverse shots. Surface anomalies also contributed to this result.

The shallower markers fade on the south eastern part of the line and their correlation from one record to another is difficult as these markers only appear on few traces at the same time.

It has not been possible to draw the interpretation diagram from the character of the arrivals without carefully checking the constancy of the gradients trace by trace and without using the same calculation velocity for the relative intercept curve.

Energy recorded is variable from one spread to another even when shooting distance and size of charge are similar.

Marker M1 first events appear on the south eastern part of the line using a shooting distance of 4.5 km. For the Base 106 M1 appears when the shooting distance is greater than 20 km.

Several anomalous areas are shown on reverse shots but do not appear on direct shots :

- A fault existing on Base 102 (recording position) fits the shape of the relative intercept curves, though its actual location and its width are not very accurately defined.
- Anomalous data provided by reverse shots on Base 101 are not found on direct shots or on the relative intercept curves.
- An area which appears on the reverse shots of Base 105 and the first part of Base 106 probably exists but the direct shots were too weak. This faulted area uncovers a new marker. In order to identify this new marker it would have been necessary to lay out additional bases. This procedure would have allowed the recording of direct and reverse shots and therefore the direct-reverse checking and the marker velocity determination.

OCR1 is too short to ensure that the marker is the same on both sides of the faulted area or if a new marker filled an important depression of Marker M1.

The velocity of Marker M1 might be 6,000 m/s. Its constant energy and the lack of faster arrivals could indicate that it is closely related to the so-called basement (Proterozoic formations).

Marker M2 is found immediately in front of Marker M1 (or M'1 where it exists).

On the south eastern part of the line the intersection of the first arrivals of marker M1 and M2 is clear and well characterized, followed by second arrivals (see Pl. 31).

Toward the north-west this intersection loses its characteristics and a strong beating effect can saturate the records when energy on both sides of the intersection remains moderate. Second arrivals were not detectable.

The peaks corresponding to marker M2 are not regular and some interferences shown on records (especially on Bases 103 - 104 shot from shot point 108/6) lead to the possible existence of two markers with closely related apparent velocities.

Interpretation of such a marker can be compared with the interpretation of a phantom horizon in seismic reflection method.

Extra shooting would be required to solve this indetermination.

Marker M3 emerges from a series of low velocity waves. It later disappears through loss of energy in front of marker M2 or when first arrivals of marker M2 and marker M3 intersect.

Marker M3 appears on a few traces and as its character is not very well defined, the corrections have been difficult from one record to another.

Therefore the interpretation of Marker M3 is not very accurate and the results have to be considered with reserve.

RELATIVE INTERCEPT CURVES EXAMINATION

(a) Marker M1.

Weak signal v. noise ratio (natural noise from the forest) and shortness of the refraction line hampered the drawing of the relative intercept curves.

Marker M1 could not be recorded from the end of Base 105 and toward the northwest using reverse shots. A possible faulted area and the emergence of a new marker could not be well defined because of the lack of direct - reverse check.

Direct-reverse check shows that the marker M1 first arrivals were not recorded on Bases 108 - 109 from shot point 102/6.

As these events were too weak to be recorded it was not possible to draw without interruption the direct relative intercept curve and it was not possible to check the velocity gradients. The part of the curve corresponding to Bases 109 to 111 was positioned using a constant K calculated as follows :

$$Ci + Ird = K$$

where : Ci = Reverse shot tying Constant

Ird = Direct shot relative intercept time

Connection through Keep River was difficult because the marker M1 and marker M2 first arrivals are intersecting on the only record available (Base 104 shot from shot point 101/6).

The constancy of the gradients is satisfactory on all the reverse shots and on the direct shots of Bases 100 to 104.

The same constant K was found all along the line and the calibration of the delay curve was accurate.

The actual velocity of 6050 m/s. is to be considered within some accuracy limits. The following is to be taken into consideration :

- Dispersal of the measurements on the convergence curve.
- Narrowness of the area where the marker remains sub - horizontal.
- Progressive variation of the offset in the strong dip area (actually progressive variation of the offset has not been applied for lack of interest).

So the marker's velocity of 6050 m/s. is accurate with $\pm$ 2% error only in the area where the marker is flat. This velocity decreases in the area where the depth of the marker decreases.

An offset of 4, 800 metres is convenient in the area where the marker is sub-horizontal but the offset decreases rapidly as the dip increases toward the south-east (the depth of the marker decreasing).

The delay-curve shows three parts :

- On the south eastern part the marker dips steeply toward the Keep River and a faulted area (or at least an anomalous area) is located at the bottom of the slope just before the river.

- The central part dips gently (almost horizontal) until the faulted area located at the centre of Base 107.

- Beyond, the delay-curve shows a strong westward dip. It should be noted that this delay-curve was extrapolated from the direct relative intercept curve only, and by assuming that the marker velocity does not change.

The delay-curve on the western part of the line is therefore not absolutely reliable as both direct and reverse relative intercept curves are needed for accurate velocity determination and for delay-curve plotting.

Smoothing of the delay curve was done according to the surface anomalies shown on the relative intercept curves in their recording position for the three markers.

(b) Marker M2

Interpretation of this marker is satisfactory on the north-west part of the line but the accuracy decreases toward the south-east. On the north western part the marker appears on sufficient traces to show that the gradients are constant despite the intermittent use of second arrivals.

A greater number of shots, and above all, a shorter distance between traces would have been necessary to enable an interpretation only based on first arrivals which are more regular and more accurate than second arrivals.

As thickness of the marker decreases towards the south-east, the number of overlapping traces recorded also decreases and verification of the gradients is less accurate.

Moreover, several phenomena shown on the records indicate that two markers could be present with very similar velocities.

Only a very heavy shooting diagram and a reduced distance between traces would have separated the two markers.

A lack of well shaped relative intercept curves makes it difficult to choose a precise offset. Therefore, the marker was interpretated using two different offsets.

Two extreme values were determined. The true offset must lie between these values.

Both delay-curves coincide when overlaid except in the south eastern part where interpretation is less accurate.

Both delay-curves show a faint anticlinal structure, whose dimension varies when the offset changes.

Whatever the offset used, the convergence curve accurately provides the true velocity of 4, 550 m/s for the Marker M2.

(c) Marker M3

An interpretation was undertaken, although a greater number of shots would have been needed for a better understanding of this shallower marker.

Here also, twice the number of shot points, together with a reduced distance between traces (120 m. instead of 240 m.) would have been necessary.

The above suggestion appeared very expensive and not quite justified at this early stage of the permit survey, but it might be useful if the marker M3 was used as reference data for the interpretation of deeper markers.

The interpretation was mainly undertaken to provide a broad outline of the marker together with its relationship to the surface elevation and the anomalies recorded on the deeper markers.

Northwest of the Keep River interpretation was satisfactory with good ties and constant gradients. Nevertheless, it cannot be certified that one distinct marker was plotted. Two very closely related markers could be present.

Southeast of Keep River a tentative relative intercept curve was drawn and it has to be considered with some reserve.

Elements of relative intercept curves were tied using only one trace so that the gradients could not be well checked.

The sole criterium used to draw this part of the curve was the retention of the constant K.

Although this is one of the criterium of the Gardner-Layat method, it is not sufficient to ensure a good interpretation.

The true velocity of 4, 075 m/s was well defined in the central part of the line. An important change in velocity is to be noted at the beginning of Base 109 (4, 350 m/s) which might correspond to a different marker but this is not clearly shown on the records.

An offset of 480 metres appears to be the best for the Marker M3.

It is pointed out that the interpretation for the Marker M3 is more qualitative than quantitative.

(d) Delay Curves

Delay curves are shown on Pl. 32 for the three interpretated markers. The delay curve for Marker M1 (considered as the basement) is well defined on the central part of the line. The accurate determination of marker depth requires a good knowledge of the average vertical velocity. If a 3,500 m/s average velocity is used between the surface and the marker M1, the depth of the marker could reach 2,500 metres. If a 3,000 m/s average velocity is chosen the depth of the marker M1 would be only of 2,100 metres at point 107/6.

These values were calculated using the following formula :

$$D = \frac{d \times Va}{\cos\alpha}$$

where D = depth in metres

d = delay-time in second

Va = average vertical velocity in metres per second between the surface and the marker considered.

α from $\sin\alpha = \frac{\text{average vertical velocity}}{\text{marker's horizontal velocity}}$

The exact angle of the strong dip shown on the south eastern part of the line (the marker coming up) cannot be accurately given.

The suggested deepening of the marker north west of Base 107 is but one of the possible solutions and should therefore be considered with reserve.

Despite some imperfections in the interpretation of marker M 2, the anticlinal structure shown on the delay curvey can be considered as true. Marker M 3 delay curve is a tentative interpretation with limited positiveness.

If, in the future, further refraction surveys are to be considered in the vicinity of the Keep River it would be advisable to restrict recording to the west bank of the river where marker dips are gentle, apart in the north of the area. Interpretation would be further improved if spreads could be laid in the area just west of the O. P. 2 permit. Shorter distances between traces and between shot points would allow a more accurate determination of the marker.

2. REFLECTION

2.1 EXPERIMENTS AND QUALITY OF RESULTS

Experiments carried out during the previous survey indicated that the results should be poor generally and would be complicated by multiples. Valuable improvement could be gained by employing six fold coverage, combined with the correct off-set, to reduce noise and suppress multiples. A trace length of 60 m. would probably give best results.

Following experiments on OC 1, a shot pattern consisting of three 60 ft. (18 m) holes in line and 10 m. apart, was selected.

As this pattern gave poor results in sandy areas, the following further experiments were tried:

- Larger trace length
- Larger shot patterns with shallower holes (15)

Fig 3

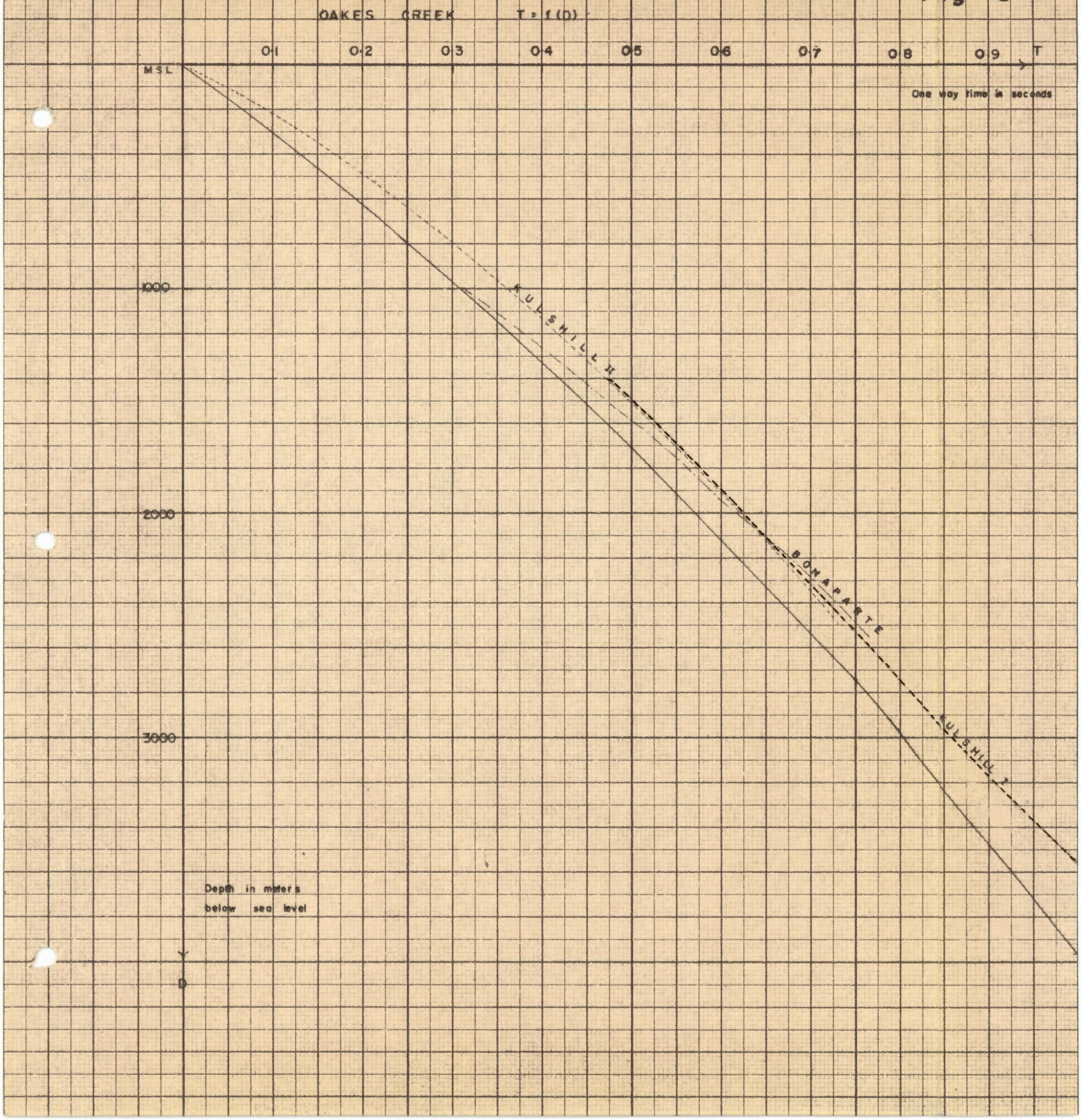

OAKES CREEK T = f(D)
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
T
One way time in seconds
MSL
1000
2000
3000
D
Depth in meters
below sea level
KULSHILL II
BONAPARTE
KULSHILL I

Fig 4

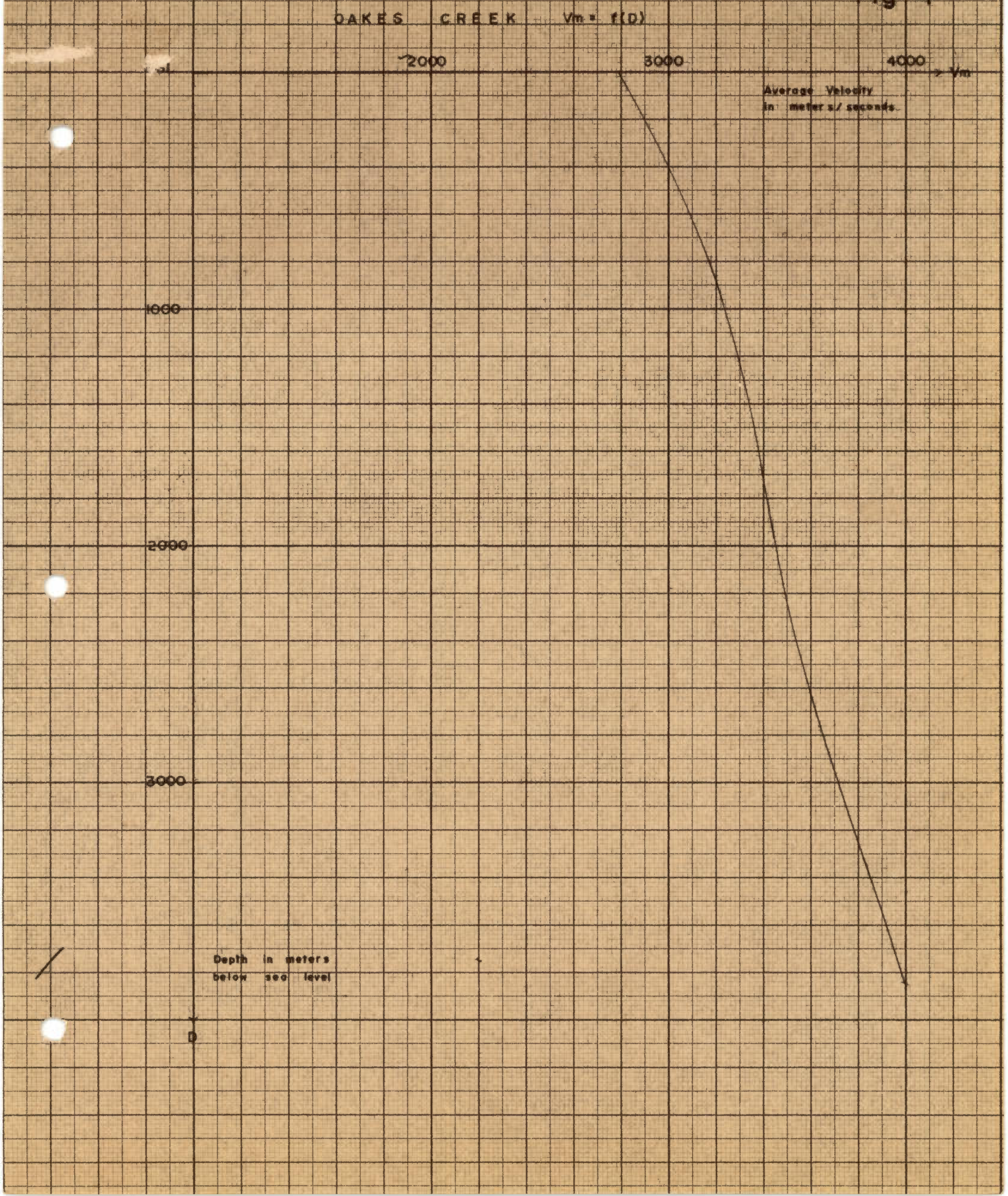

OAKES CREEK Vm = f(D)
2000
3000
4000
Vm
Average Velocity
in meters/seconds.
1000
2000
3000
Depth in meters
below sea level
D

Fig 5

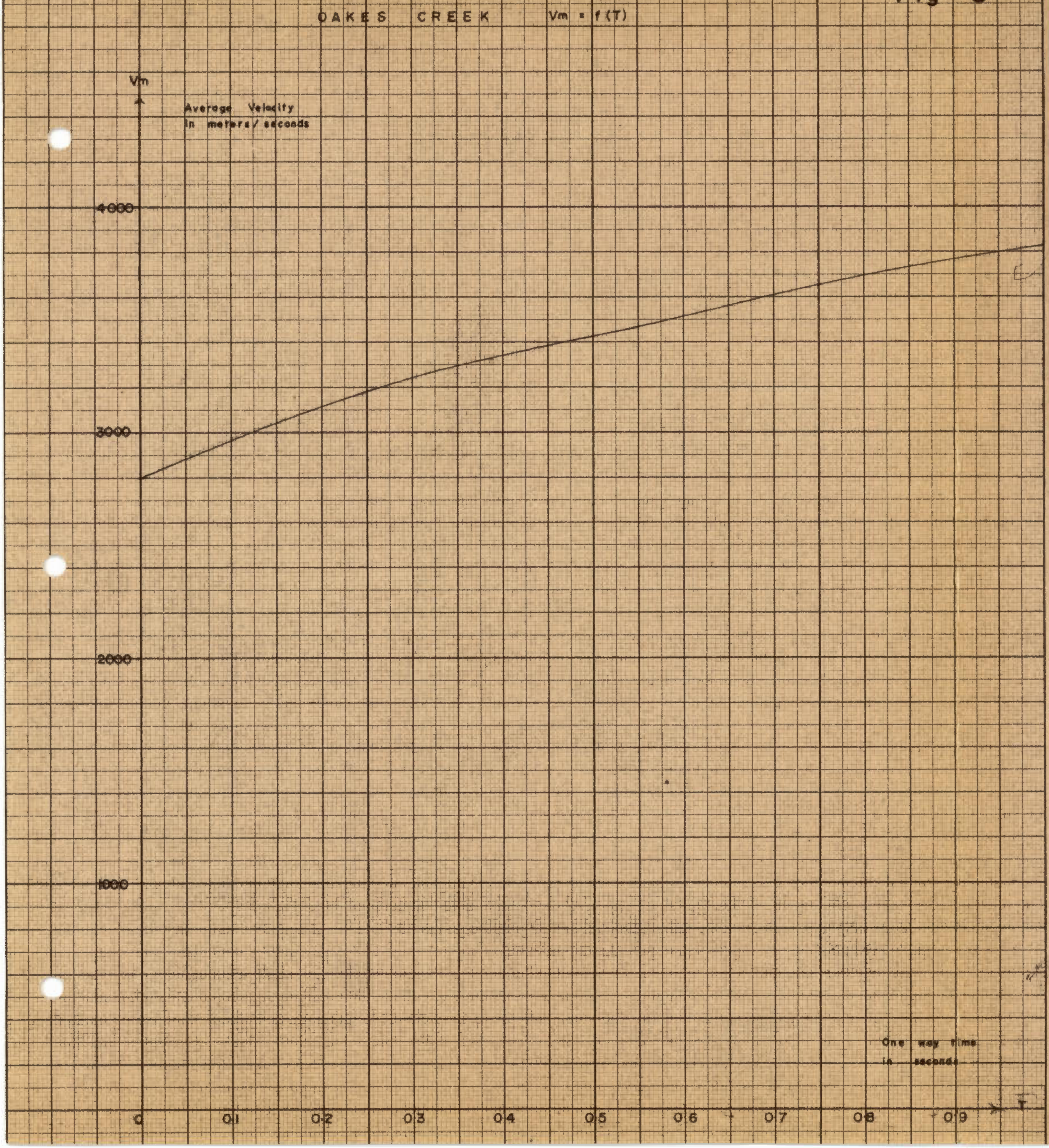

OAKES CREEK Vm = f (T)
Vm
Average Velocity
in meters / seconds
4000
3000
2000
1000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
T
One way time
in seconds

Fig 6

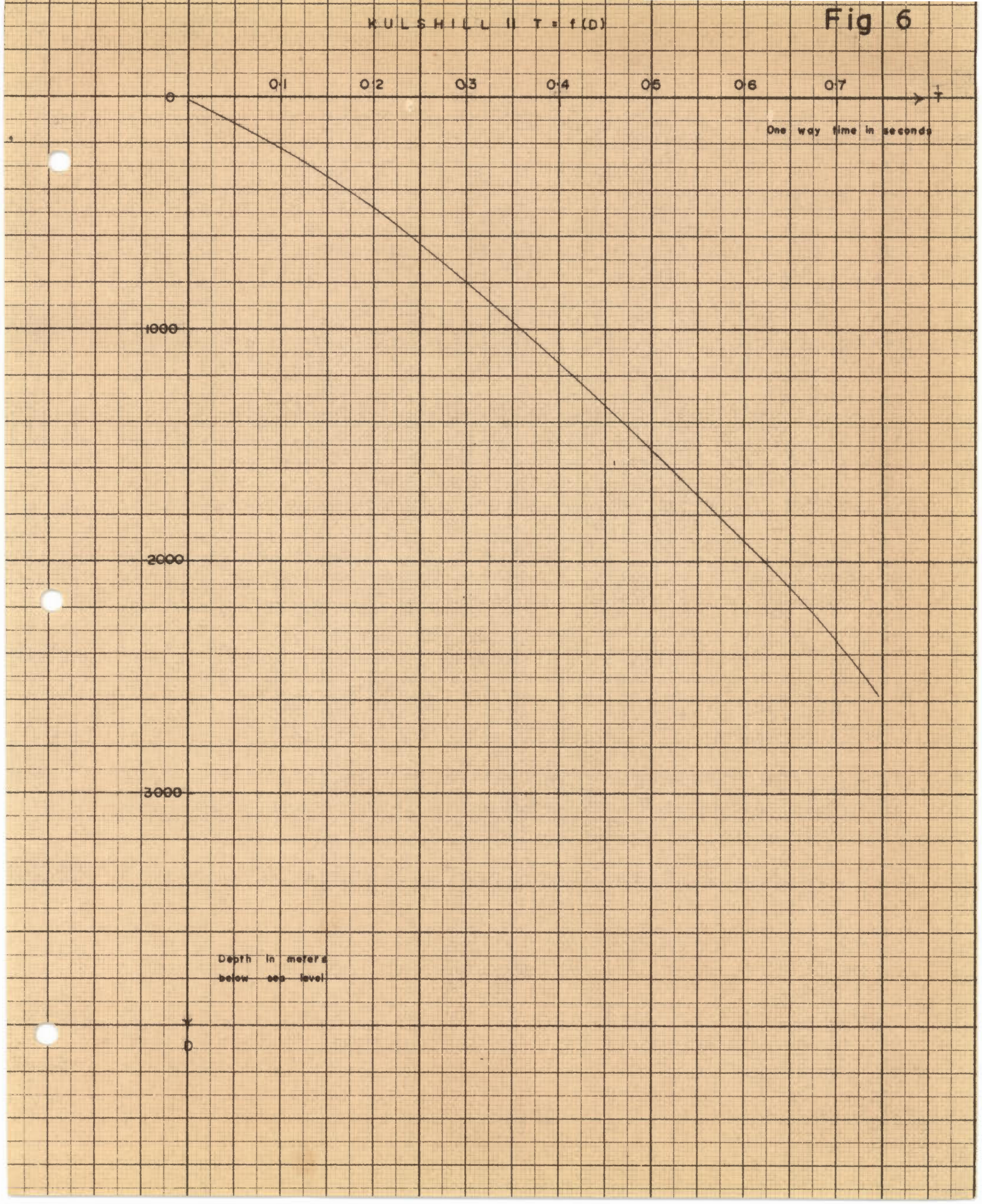

KULSHILL II T = f(D)
0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
T
One way time in seconds
1000
2000
3000
Depth in meters
below sea level
D

Fig 7

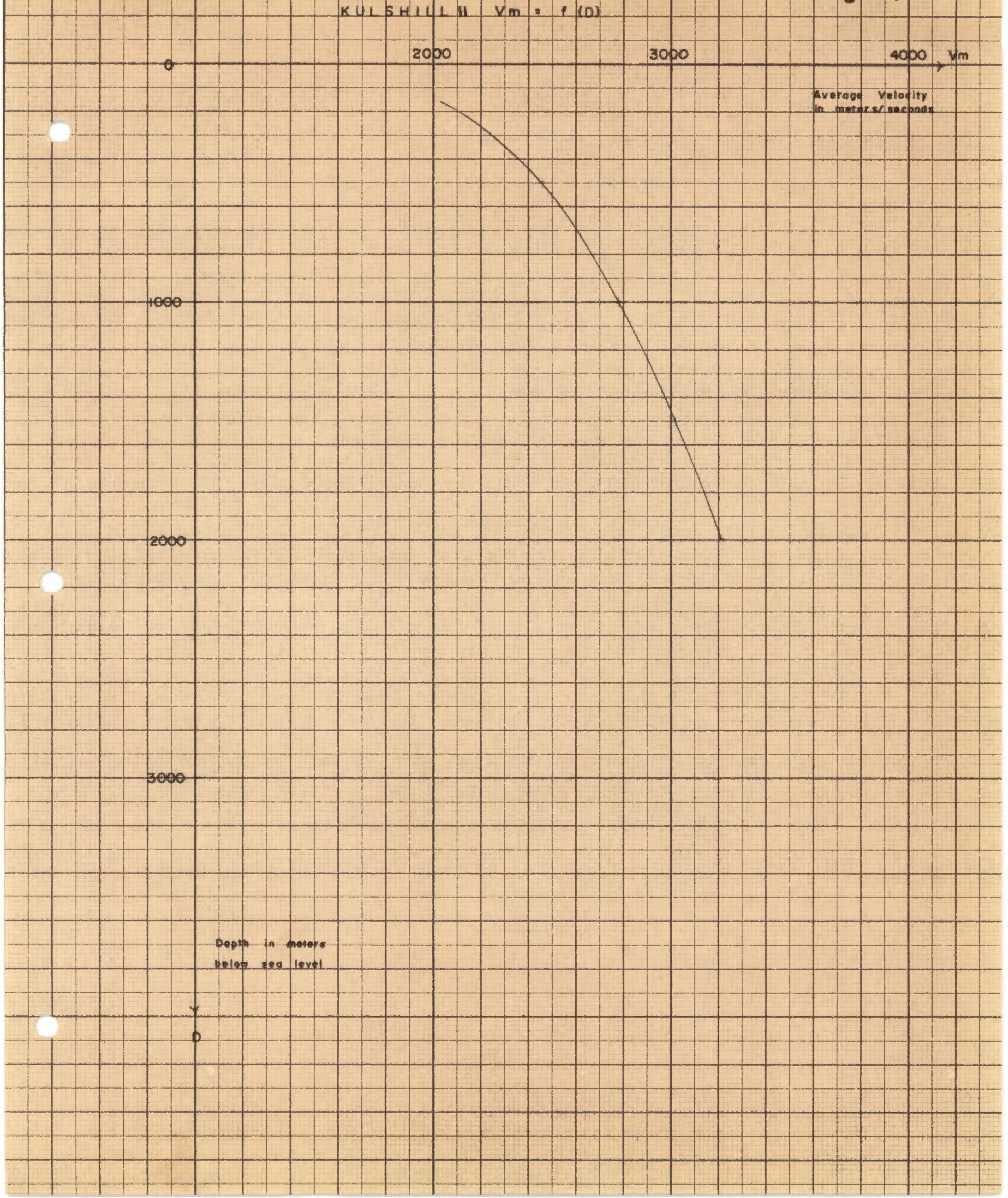

KULSHILL II Vm = f (D)
2000
3000
4000
Vm
0
Average Velocity
in meters/ seconds
1000
2000
3000
Depth in meters
below sea level
D

Fig 8

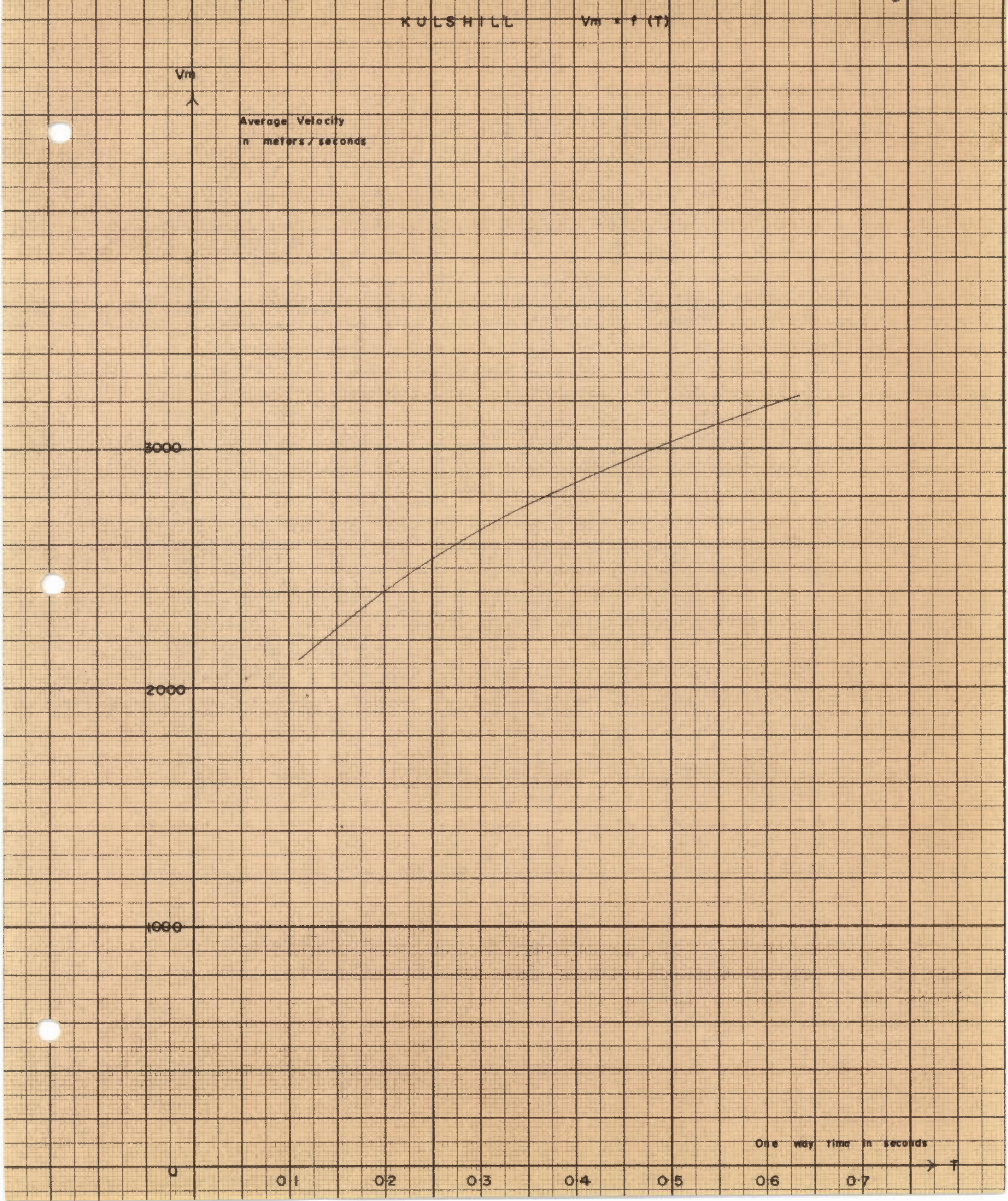

KULSHILL Vm = f (T)
Vm
Average Velocity
in meters / seconds
3000
2000
1000
0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
One way time in seconds
T

Fig 9

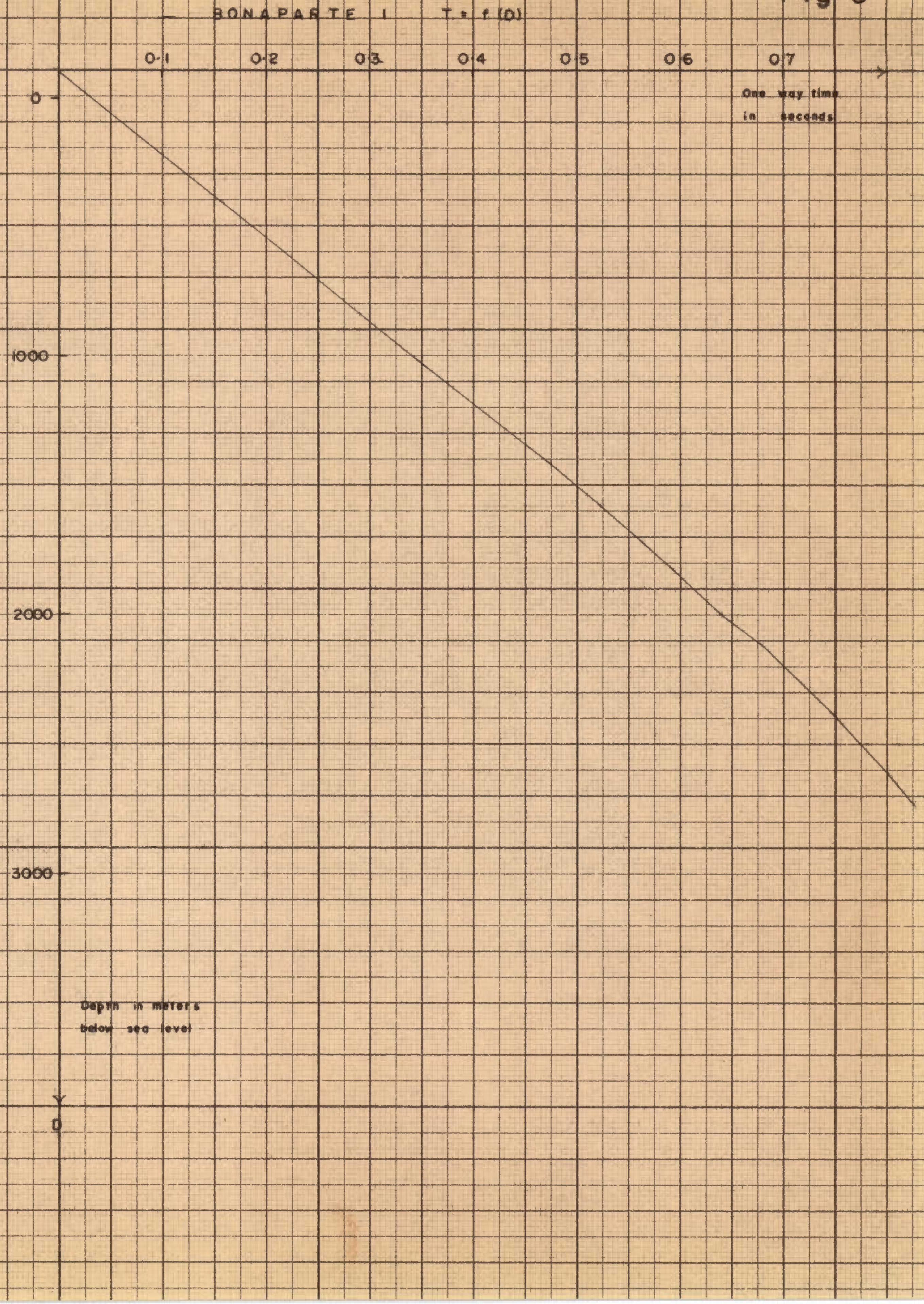

BONAPARTE 1 T = f (D)
0·1
0·2
0·3
0·4
0·5
0·6
0·7
One way time
in seconds
0
1000
2000
3000
Depth in meters
below sea level
D

Fig 10

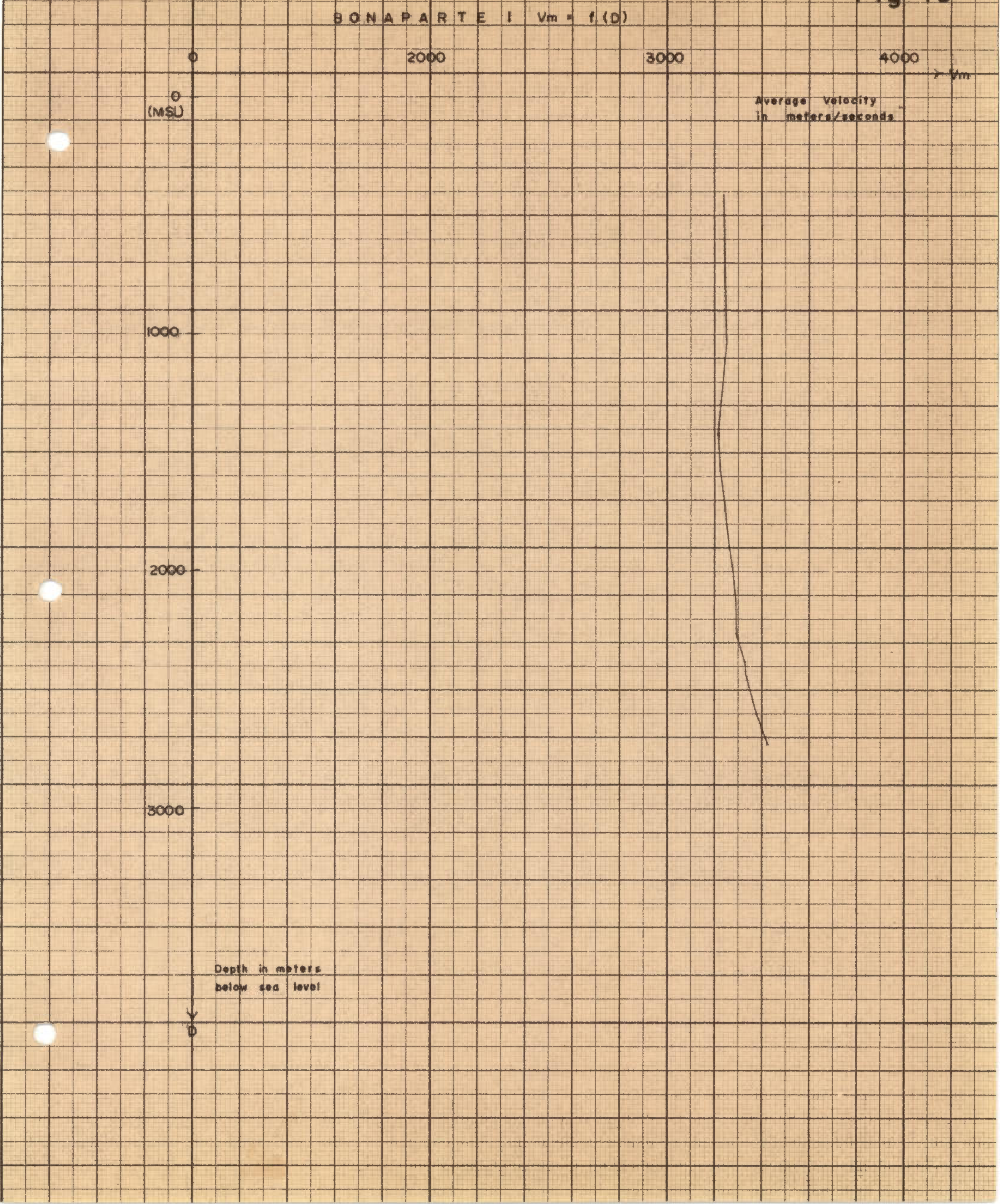
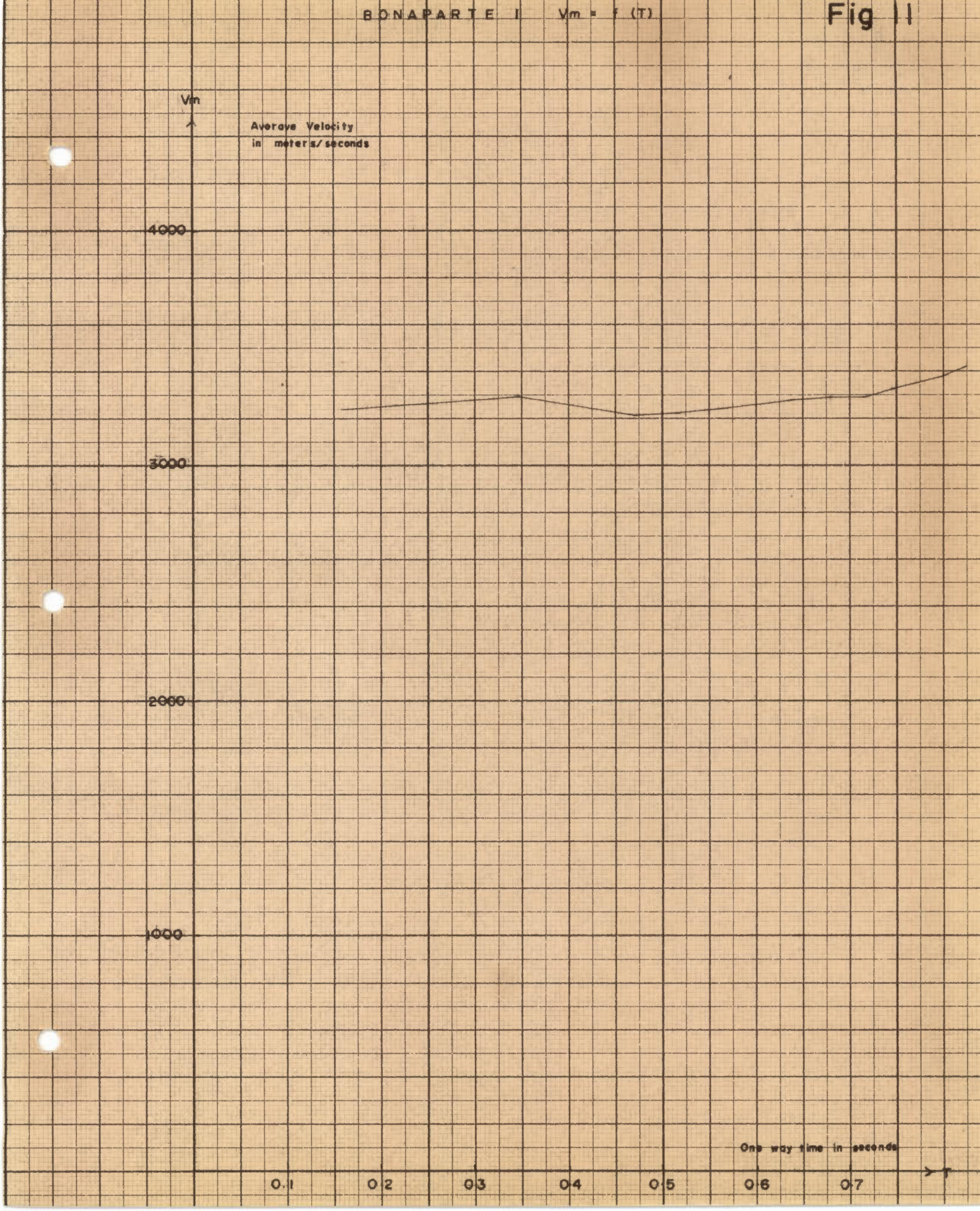

BONAPARTE I Vm = f (D)
0
2000
3000
4000
Vm
0
(MSL)
Average Velocity
in meters/seconds
1000
2000
3000
Depth in meters
below sea level
D

Fig 11


BONAPARTE I Vm = f (T)
Vm
Average Velocity
in meters/seconds
4000
3000
2000
1000
0.1
0.2
0.3
0.4
0.5
0.6
0.7
One way time in seconds
T

- Increased number of geophones.

Increasing the number of geophones from 36 to 72 gave improved reflections quality.

The larger shot pattern with shallow shot holes gave no improvement in results, due to the depth and consistancy of the weathering zone producing loss of energy.

A break down of record quality gives the following :

Good	10%
Fair	20%
Poor	50%
Very poor	20%

The worst results were recorded in high, dry, sandy areas. A direct relationship can be observed between the elevation curve and the quality of the section. Much better results were obtained in low areas of mud and salt flats.

Records were poor on OC2 and it appears to have been shot in a fault zone.

The records were good on OC 3 and OC 4, due to the fact that these lines were shot on synclinal folds giving a concentration of energy. The quality of sections was improved in most cases by six fold stacking. However, on OC 7, a strong apparent reflection on the play-back disappeared on the section. It is assumed that it was in fact a multiple.

2.2 FIELD COMPUTATION

Velocity Function. With six fold coverage and long spreads it is essential to use the right velocity law. The average N.M.O. curve gives a slow velocity function that we chose. Trials at the G.S.I. processing centre confirmed this velocity function. Figs. 3 to 11 compare Oakes Creek velocities with Bonaparte and Kulshill velocity logs.

- Approximate velocity function : 3000 m/s + 0.12 Zm
- Altimetric correction velocity : Vc = 3000 m/s
- Homogeneous velocity : Vh = 3640 m/s

Surface Conditions. The Weathering zone was changing continually. A Weathering shot was made every 10 shot points. The velocity under W-Z was 3000 m/s and this velocity was used for altimetric corrections.

Static Corrections. The quality of the results provided few opportunities to use the template method of static corrections. However, this method was used whenever possible. The altimetric method gave poor results because of the variable surface conditions. For these reasons first arrivals were generally used, taking into account the value of Cs + VT (elevation correction for the top of the charge + vertical time).

2.3 PRESENTATION OF RESULTS

Each shot is recorded in a monitor and a play back. (Filter settings 1 - 16, 1 - 40, AGC Medium, Gain : Initial 30, Final 20).

Two sections have been made for each line. One without deconvolution

(Filter settings 18 - 47, AGC Medium) and one with deconvolution (Filter settings 16 - 47, AGC Zero).

The sections were produced by G. S. I. using digital methods. For comparison one single coverage section (OC1) and one deconvolved section with AGC and different filter settings (OC4) has also been provided. Plates 16 and 24.

2.4 INTERPRETATION

The choice of the markers selected was governed by two necessities :

- That multiples should not be selected, and
- The need to select a marker which was continuous over the whole surveyed area.

By comparing sections with and without deconvolution two markers have been selected.

The first about 1100 ms. (two way time) is complicated by multiples on sections without deconvolution, but appears much clearer on deconvolved sections. This marker has been called Horizon H1.

The second, dipping from 1400 ms to 1800 ms (two way time), is characterized as being the first marker with dip. It is interrupted by interference from a multiple of Marker A and in this interference zone it is easy to lose one phase. However, it can be recognised by its character and by comparison with the deconvolved section. The marker has been called Horizon H2.

The main problem in the interpretation arose because of the very poor results from areas adjacent to OC2. By careful use of results from OC4, OC6 and

OC 5 it was possible to close the eastern ends of OC 1 and OC 10. Closures involving combinations of OC 2 with north-south lines were not possible.

The Oakes Creek area is effected by the interaction of two fault systems. The first running north-south (two synclines on OC 3 and OC 4) can be correlated with the Burt Range. The second trends east-west and gives the faulted area observed in the vicinity of OC 2. North of OC 2, the folding is more pronounced than it is to the south as can be seen on OC 1 and SC 1 (see Skull Creek Report).

The interpretation (see Plates 40 and 41) indicates a structure between OC 1, OC 2, OC 11 and OC 3.

3. GRAVITY

Gravity observations were based on the PETTY value of the Legune Airstrip Windsock. Ties were made to other stations such as L 10 (Misclosure 0.06 mgal) and G 245 (Misclosure 0.04 mgal).

The maximum loop misclosure was 0.09 mgal.

The difference between C. G. G. and PETTY Bouguer Anomaly values resulted from the different elevations used by the two companies. PETTY elevations were based on an assumed value of 75 ft. for the Legune Airstrip Windsock. C. G. G. elevations were based on the best known elevations (A. M. S. L.) for the Weaber and Wicklow trig stations giving a value of approximately 51 feet for the Legune Windsock. This 24 ft. difference is reflected in the 1 to 2 milligal difference in Bouguer Anomaly values.

Apart from this difference, the main features are the same for both surveys. Bouguer Anomaly values decrease towards the north. Very sharp local variations appear in the faulted zone on OC 2, due to shallow events. Two gravimeters were used and provided excellent checks on the accuracy of observations.

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

GRAVITY

A northward dipping basement is indicated.

REFRACTION

Basement has been established as Proterozoic. Basement disposition has been fixed. An anticline is indicated in the upper layers.

REFLECTION

The existence of two faulting systems (north-south and east-west) has been established. Two markers have been picked and indicate an anticline.

Remark

Reflection records though poor to fair could be interpreted.

Refraction results in the neighbourhood of OC 2 (initially considered poor) can now be up-graded in the light of the more accurate structural picture of the area now available and a faulted area is indicated.

Respectfully submitted,

G Joneaux

Interpreted by :
G. JONEAUX

J. M. CUNIN
Australian Branch Manager.

APPENDIX I

INSTRUMENTATION

1. REFLECTION

Recording equipment P. T. 100

Recording filters :

Low cut	1/16
High cut	1/78
A. G. C.	Fast
Initial gain	40 dB
Final gain	0 dB
Delay on trace 1	

2. REFRACTION

Recording equipment P. T. 100

Recording filters :

Low cut	out
High cut	125
A. G. C.	zero
Gain	see statistical diagram.

3. GRAVITY

Two gravimeters WORDEN PIONEER were used during the survey. Calibration is shown in Figs. 15 and 16.

4. PECULIAR PROBLEM DUE TO AMPLIFIER

Examination of monitors shows a constant delay in the amplifier that does not exist on the T. B. trace. This gives an apparent advance of the T. B. trace over recording traces. Field tests showed that this was neither due to the shooting box nor to shooting line or detonators.

By recording another T. B. on trace 12, an analysis of the delay was possible. The delay was constant on OC1 and OCR1 and equal to 13 ms. Following a circuit adjustment, the delay was reduced to 9 ms, and this value applies to all lines other than OC1 and OCR1. See figure 18.

All computation (refraction, reflection and W. Z.) has been corrected for this delay. However, if further utilisation of tapes and play-backs is to be made, careful attention must be paid to these delays.

It has been further confirmed by SIE that this delay is caused by the EF 5656 aliasing filter and is constant for all channels.

EXPERIMENTS

FIG. 12

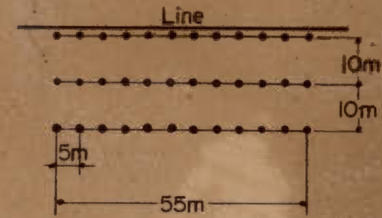
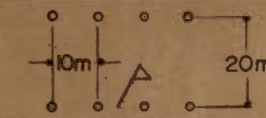
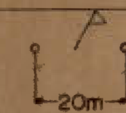
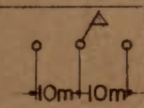
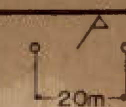
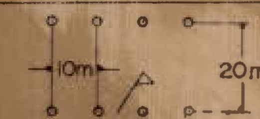
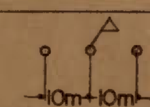
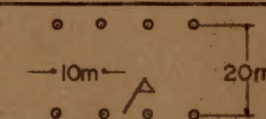
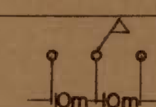
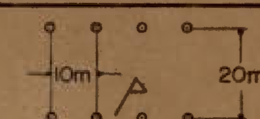
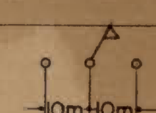
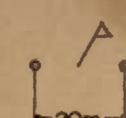
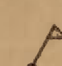
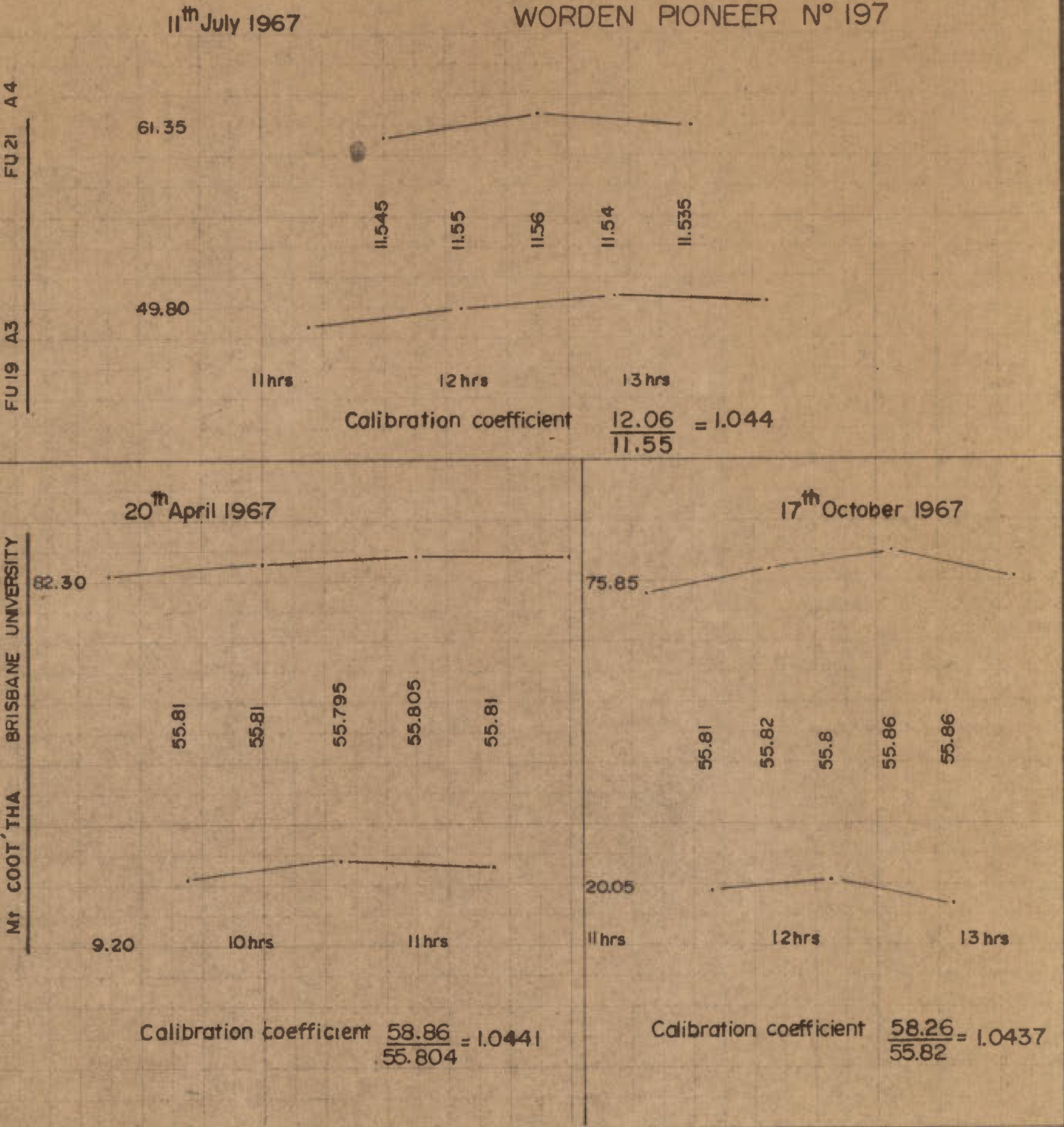
LINE	SP	Shot Number	Geophones		Holes				Remarks
			Number	Pattern	Number	Depth	Charge	Pattern	The mark * is applied to the best film
OC1	1	1	36		8	10m	8x5lb		*The three films are similar*
"	1	1	"		2	24m	2x20lb		*
"	1	2	"		3	10m	3x5lb		
"	2	3	"	"	2	26m	2x20lb		*Strongest arrivals but more noisy*
"	2	4	"	"	8	10m	8x5lb		* *Best signal/noise ratio, no superposition of 2 films*
"	3	5	"	"	8	10m	8x5lb	"	*The 2 films are superimposable*
"	3	6	"	"	3	18m	3x15lb		* *the deeper shot is the best*
"	4	7	"	"	8	10m	8x5lb		* *2 films not similar the pattern is the best*
"	4	8	"	"	3	18m	3x15lb		*This film gives more low frequencies*
"	5	3	"	"	8	18m	8x5lb		* *The two films have a good superposition*
"	5	4	"	"	3	10m	3x15lb		
"	7	6	"	"	3	18m	3x15lb		* *The films 6 & 6A are very similar to*
"	7	6A	"	"	3	18m	3x15lb		
"	7	6B	"	"	1	18m	1x20lb		*6B. & 7 but better*
"	7	7	"	"	1	18m	1x20lb		

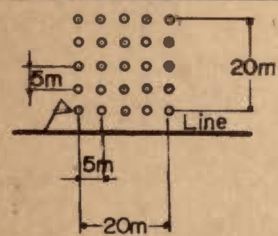
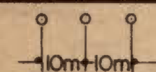
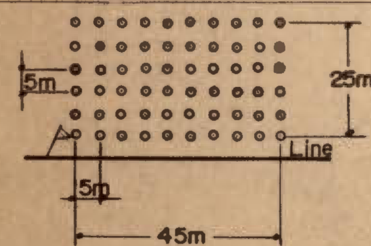
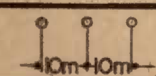
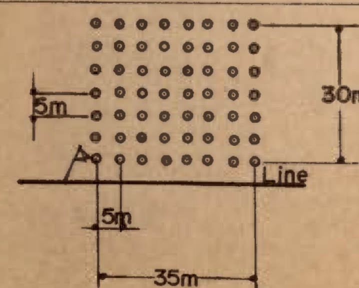
Fig 15

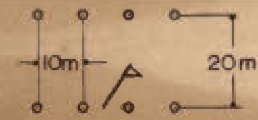
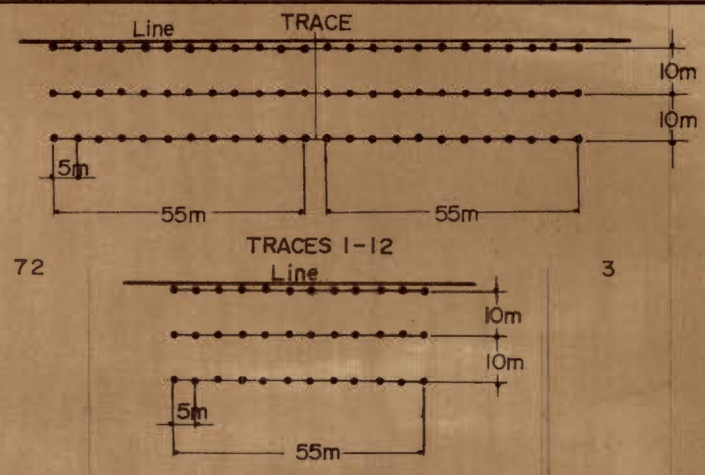
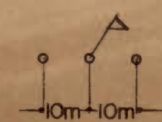
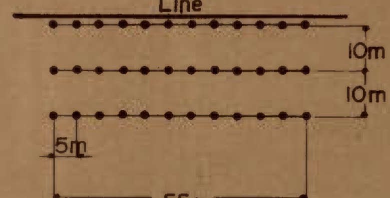
GRAVIMETER CALIBRATION



Calibration coefficient = 1.0441

FIG.14

LINE	SP	Shot Number	Geophones		Holes				Remarks
			Number	Pattern	Number	Depth	Charge	Pattern	The mark * is applied to the best film
OC8	681	16	36	As previous page	3	18m	3x40lb	As previous page	For the corresponding
"	681B	9	"	"	"	"	"	"	* traces the results are
"	682	17	"	"	"	"	"	"	similar appart from
"	682B	11	"	"	"	"	"	"	* before the delay times.
"	683	18	"	"	"	"	"	"	For the other traces the
"	683B	13	"	"	"	"	"	"	* films B look better
"	684	20	"	"	"	"	"	"	
"	684B	15	"	"	"	"	"	"	*
OC9	750	2	"	"	"	"	"	"	* Both films quite
"	750	3	"	"	25	5m	25x10lb		different, 750/2 looks better
OC10	838	24	"	"	3	18m	3x40lb		* As above
"	838	25	"	"	60	3m	60x25lb		Too weak
"	851	4	"	"	3	18m	3x40lb		
"	851A	5	"	"	56	3m	56x5lb		As ~~above~~

LINE	SP	Shot Number	Geophones Number	Geophones Pattern	Holes Number	Holes Depth	Holes Charge	Holes Pattern	Remarks **FIG.13**
									The mark * is applied to the best film
OC I	10	10	36	As previous page	3	18m	8x5lb		*
"	10	11	"	"	8	5m	8x5lb	"	Too weak, more low frequencies
"	11	12	"	"	8	10m	8x5lb	"	* One sees the reflections better
"	11	13	"	"	8	5m	8x5lb	"	Too weak, more low frequencies
"	12	14	"	"	8	10m	8x5lb	"	More high frequency noise
"	12	1	"	"	8	5m	8x5lb	"	* The films are not similar
"	13	2	"	"	8	10m	8x5lb	"	* Bad batch of them
"	13	3	"	"	8	5m	8x5lb	"	No superposition
OC8	669	13	72		3	18m	3x30lb		* The reflections appear better on 72 sismo pattern. This experiment takes place on sand
"	669	14	36		3	18m	3x40lb	"	
"	680	14	"	"				"	Some patterns sismo and shot point but
"	680B	7	"	"				"	* Shots 13 between trace 20 & 21

APPENDIX 11

HISTORICS AND STATISTICS

1. HISTORICS

1. 1 DRILLING

1st hole drilled	31st July, 1967.
Last hole drilled	12th October, 1967.

1. 2 RECORDING

1st shot point reflection OC 1	1st August, 1967.
Last shot point OC 1	11th August, 1967.
1st shot point refraction OCR 1	13th August, 1967.
Last shot point refraction OCR 1	27th August, 1967.
1st shot point reflection OC 2	28th August, 1967.
Last shot point reflection OC 11	14th October, 1967.

1. 3 GRAVITY

First reading	4th August, 1967.
Last reading	8th October, 1967.

2. STATISTICS

See figure 18.

APPENDIX III

VEHICLES AND EQUIPMENT

SEISMIC PARTY

Land Rovers	9
Office Trailer	1
International AB 160 4 x 4	1
PT 700 and PMR 20	1
HS-J Geophones	1390
LI-B Geophones	300
International AB 160 water truck	1
International AB 160 supply truck	1
Kitchen Trailer	1

DRILLING PARTY

Land Rover	1
International R 190 4 x 4	4
Mayhew 1000 Drill	4
Air compressor	4
Mud Pump	4
Workshop Trailer	1

APPENDIX 1V

PERSONNEL

SEISMIC PARTY

Party Chief	1
Chief Computer	1
Computer	1
Administration Assistant	1
Surveyor	1
Rodmen	3
Observer	1
Junior Observer	1
Linesmen	10
Shooters	2
Cooks	2
Assistant Cook	1
Camp Helpers	2
Mechanics	1
Mechanic Helper	1

DRILLING PARTY

Field Manager	1
Drillers	4
Driller Helpers	4
Mechanic Helper	1

GRAVITY PARTY

Gravity operators	2

APPENDIX V

LIST OF PERMANENT MARKERS

Line	Number	X	Y	Z
OC 1	14	514,467.1	8,321,867.0	25.44
	30	512,614.9	8,322,333.0	20.53
	33	512,266.6	8,322,420.7	18.55
	69	508,079.9	8,323,489.7	23.82
	90	505,643.4	8,324,125.8	24.00
	96	504,937.7	8,324,311.2	17.91
OC 2	97	501,121.5	8,320,639.9	33.22
	120	503,807.6	8,319,977.5	29.43
	141	506,254.5	8,319,367.7	40.18
	159	508,351.3	8,318,843.9	36.24
	178	510,567.7	8,318,246.9	29.34
	195	512,552.8	8,317,796.6	16.19
OC 3	331	504,526.9	8,315,327.2	25.20
	349	504,386.8	8,317,308.0	34.10
	368	506,301.3	8,319,396.7	40.40
	386	507,167.1	8,321,374.5	38.33
	405	508,080.2	8,323,463.2	23.62
	450	510,239.7	8,328,400.7	13.63
OC 4	218	508,842.5	8,314,311.3	26.75
	235	509,641.1	8,316,191.4	20.18
	241	509,922.7	8,316,851.3	16.67

Continued......

Line	Number	X	Y	Z
OC 4	254	510,535.9	8,318,284.9	29.79
	291	512,274.2	8,322,365.6	18.47
	321	513,683.4	8,325,666.6	17.70
OC 5	457	511,931.3	8,316,618.9	15.48
	459	512,035.7	8,316,834.7	16.40
	468	512,505.4	8,317,806.0	16.05
	506	514,485.3	8,321,906.0	25.89
	532	515,839.9	8,324.712.4	17.07
OC 6	539	509,897.6	8,316,828.0	16.60
	556	511,927.6	8,316.638.2	15.73
OC 7	566	501,431.9	8,316,060.5	48.59
	584	502,301.0	8,318.034.9	38.38
	603	503,220.5	8,320,112.4	24.74
	635	504,763.3	8,322.603.9	16.59
	641	505,055.5	8,324.261.2	20.09
OC 8	674	500,032.5	8,316,315.6	42.29
	686	501,427.3	8, 316,002.3	48.63
	713	504,586.6	8,315,291,2	24.55
	731	506,689.8	8,314,817.3	21.60
	749	508,791.3	8,314,343.9	27.35
OC 9	755	499,958.0	8,316,207.2	40.39
	775	500,974.7	8,318,379.4	31.57
	793	501,889.2	8,320,339.4	23.77

Continued ......

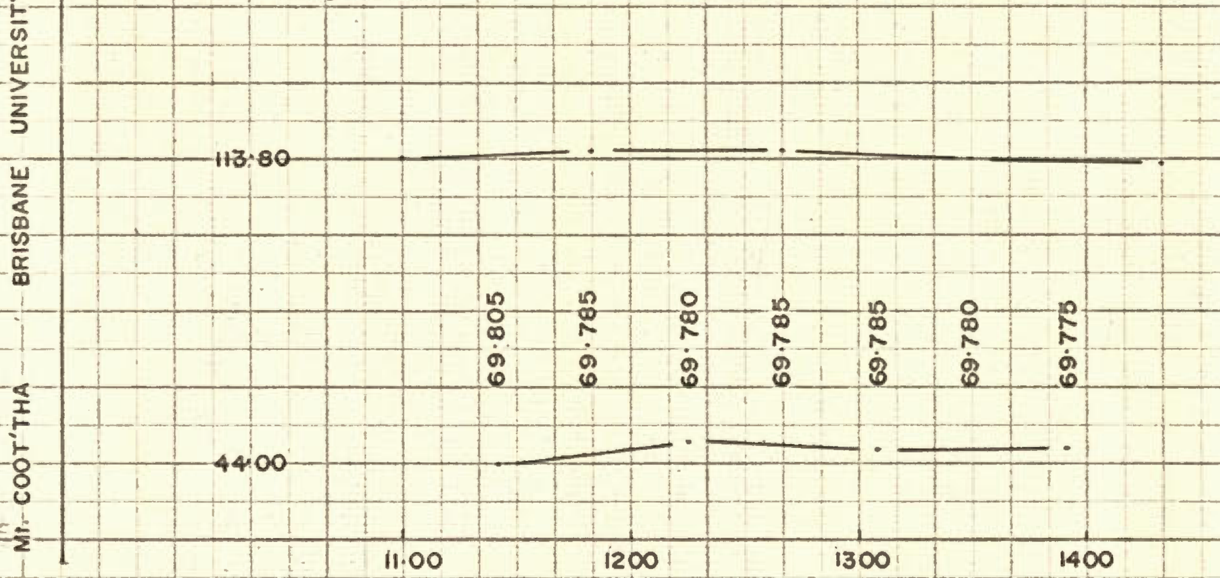
Line	Number	X	Y	Z
OC10	808	500,959.3	8,318,390.0	31.70
	820	502,351.4	8,318.028.0	38.51
	846	505,371.5	8,317.255.6	35.16
	864	507,461.3	8,316,722.2	25.62
	882	509,556.2	8,316,187.5	20.34
OC11	889	506,655.2	8,314,821.8	21.51
	906	507,453.3	8,316,696.9	25.79
	925	508,346.5	8,318,792.1	35.78
	935	508,814.9	8,319.895.0	32.37
OCR1	98/6	526,841.9	8,303,157.7	17.53
	100/6	522,687.0	8,307,034.7	17.20
	101/6	520,580.9	8,308.994.2	18.28
	103/6	516,343.9	8,312,904.1	19.37
	105/6	511,855.8	8,317,082.8	19.12
	107/6	507,624.8	8,320,997.1	40.65
	109/6	503,379.8	8,324,902.2	17.95
	111/6	499,112.2	8,328,787.3	18,66
OCR2	198/6	526,882.9	8,306,496.6	17.20
	202/6	515,430.9	8,307,927.0	18.86
	203/1	513,766.6	8,308,147.0	19.41
	205/7	506,621.4	8,309,058.4	22.07
	208/6	498,276.3	8,310,151.1	34.26

Previous permanent markers	X	Y	Z
BM1	511,636.2	8,313,713.8	17.48
SC2	512,719.4	8,313,476.5	17.37
SC1 PM37	519,116.0	8,326,890.9	23,54
AAPBM2	514,010.2	8,325,456.9	13,30
PM109	521,770.1	8,307,009.8	17.50
PM 62	504,639.5	8,305,246.5	33.55
PM 54	508,882.6	8,305,272.7	17.11
PM 11	506,065.8	8,314,954.6	21.96
PM 22	500,377.9	8,316,236.2	47.02
PM 71	499,875.0	8,305,211.7	46.85
M60N	499,909.9	8,304,774.6	40.90
PM122	519,039.8	8,313,418.2	16.84

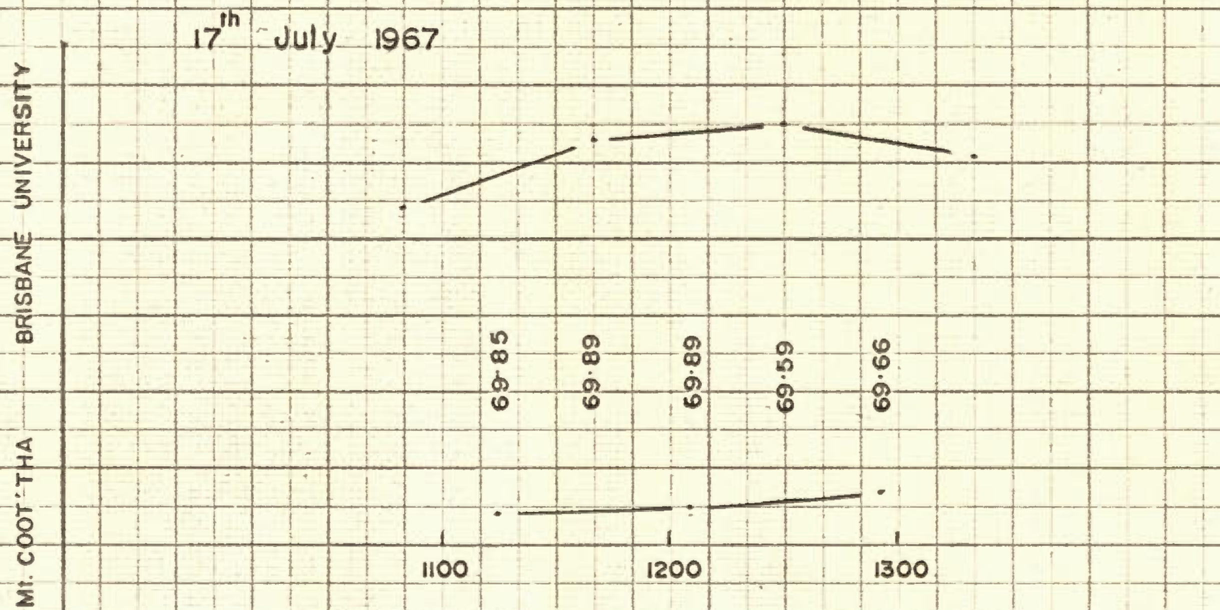
Fig 16

GRAVIMETER CALIBRATION

WORDEN PIONEER N°708



Calibration Coefficient $\frac{58\cdot26}{697\cdot85} = 0\cdot8345$



Calibration Coefficient $\frac{58\cdot26}{69\cdot85} = 0\cdot8340$

Chosen Coefficient = 0·8345

STATISTICS OAKES CREEK SEISMIC AND GRAVITY SURVEY 1967 Fig 17

SEISMIC and GRAVITY

Reflection

Month	Type of Work	Line	Recording Time: Production	Recording Time: Travel	Recording Time: Standby	Recording Time: Total	Production: New Spread	Production: Reshot	Production: Replaced	Production: No. of Shot	Production: Offset Shot	Production: WZ Shot	Production: New kms.	Ratios: Shot prod. hr.	Ratios: New Km per prod. hr.
Aug.	Reflection Refraction	OC1,OC2 OCR1	93.75			93.75	156	13		169		15	21.36	1.803	.228
Sept.	Reflection	OC2,4,3, OC5,6,7,8	229			229	529	7	1	537		42	71.40	2.345	.312
Oct.	Reflection	OC8, 9, 10, 11	93.50		19*	112.50	249	3		252		23	33.64	2.695	.360
Total			416.25		19	435.25	934	23	1	958		80	126.40	2.301	.303

Refraction, Total Time, Gravity

Month	Recording Time: Production	Recording Time: Travel	Recording Time: Standby	Recording Time: Total	Production: New Bases	Production: Reshot	Production: WZ Shot	Production: No. of Shot	Production: New Km.	Ratios: New bases prod. hr.	Ratios: Shot per prod. hr.	Ratios: New km. per prod. hr.	Total Time: Production	Total Time: Travel	Total Time: Standby	Total Time: Total	Gravity: New Stations	Gravity: Repeated Stations	Gravity: New Bases	Readings	Remarks
Aug.	96.25	3.50		99.75	12		10	96	34.56	0.125	0.997	0.36	190	3.5		193.5					
Sept.													229			229	393		33	1044	
Oct.													93.5		19	112.5	49	20	3	103	* Waiting for explosives, carrier break down on its way
Total	96.25	3.50		99.75	12		10	96	34.56	0.125	0.997	0.36	512.5	3.5	19	535	442	20	36	1147	

DRILLING

Month	Type of Work	Drilling Time: Production	Drilling Time: Travel	Drilling Time: Standby	Drilling Time: Total	Production: S.P.	Production: Holes	Production: Footage	Ratio: Ft. per Production Hour
July	Reflection	7.00			7.00	2	17	660	94
July	Refraction								
Aug.	Reflection	375.25	8.50		383.75	202	716	39300	105
Aug.	Refraction	264.25	9		273.25	30	323	15885	60
Sept.	Reflection	930.25			930.25	530	1624	96265	103
Sept.	Refraction								
Oct.	Reflection	386.5			386.5	202	734	38190	99
Total	Reflection	1699.00	8.50		1707.50	936	3091	174415	103
Total	Refraction	264.25	9.00		273.25	30	323	15885	60
Total	Total	1963.25	17.50		1980.75	966	3414	190300	97

DOZING

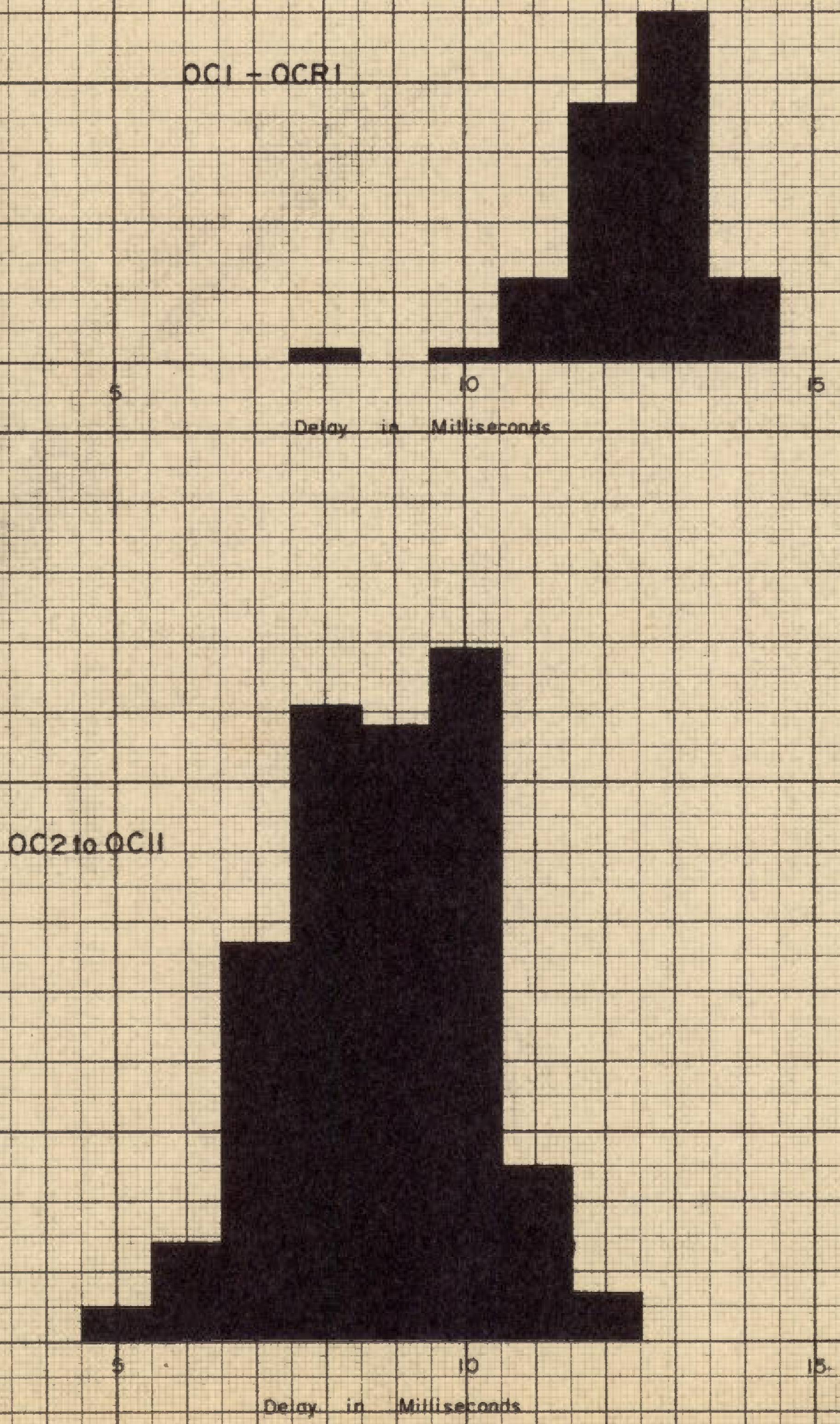
Month	Hours S=Reflection R=Refraction	Walking	Dozing Access	Standby	Total
July	S 37.50 R 144	35.00	47.00		263.50
Aug.	S180.50 R127.50	53.00	39.00		400.00
Sept.	S158.00 R 61.00	28.50	11.00	56.00	314.50
Oct.	S 51.00	18.00		62.00	131.00
Total	S 427.00 R332.50 759.50	134.50	97	118	1109.00

CONSUMABLE STORES

Month	Type of Work	Explosives: 10 lbs	Explosives: 5 lbs	Detos: 30'	Detos: 60'	Starter 5 5/8"	Skidmore 3" Blades 4 3/4	Skidmore 5" Blades 5 7/8	Insert 3" Vard 4 3/4	Insert 3" McD 4 3/4	Walker 3" Rock 4 3/4	Hughes H 3" Rock 4 3/4	VH1	V 2	API Sub 2 7/8"	API Sub 2 3/8"		Skid 3 way Head Ass.		Permanent Marker (ft)
July	Reflection						1		1											
Aug.	Reflection Refraction	 14505	8985 		345 292	21	31		9	21	3		7	3	1	2		2		
Sept.	Reflection	32670	16015	427	2162	12	28		14	70			9	2	2	3		2		539
Oct.	Reflection	32475			1574	2		17		12		14	3	6				4		264
Total	Reflection	65145	25000	427	4381															
Total	Refraction	14505			292															
Total	Total	79650	25000	427	4573	35	60	17	24	103	3	14	19	11	[illegible]	5		8		803

Fig. 18

TB DELAY STATISTICS



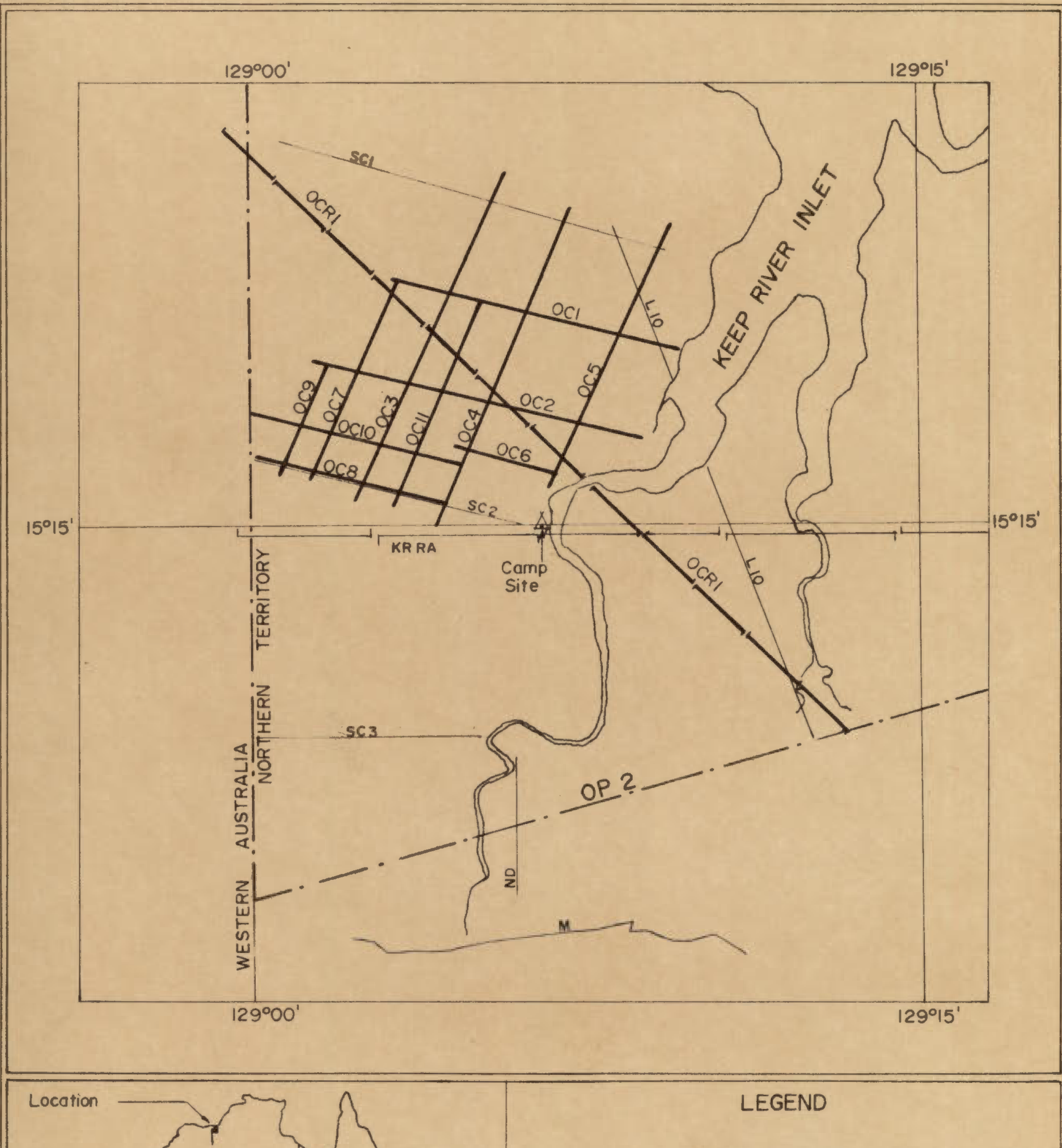
C.G.G. S6521 A.A.P

FIG. 19

OAKES CREEK SEISMIC AND GRAVITY SURVEY

SCHEMATIC LOCATION MAP

SCALE 1/250,000



LEGEND

C.G.G. Line 1967 Reflection

Refraction

Lines previously shot referred to in the text:

Reflection

Refraction