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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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OTWAY AND SYDNEY BASINS EXPERIMENTAL "VIBROSEIS" SURVEY, 1964

Seismograph Service Limited

HOLWOOD KESTON ENGLAND

FINAL FIELD AREA REPORT

ON AN

EXPERIMENTAL VIBROSEIS * SEISMIC SURVEY

IN THE

OTWAY AND SYDNEY BASINS

FOR THE

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

BY

SEISMOGRAPH SERVICE LIMITED

DURING

MAY - OCTOBER, 1964

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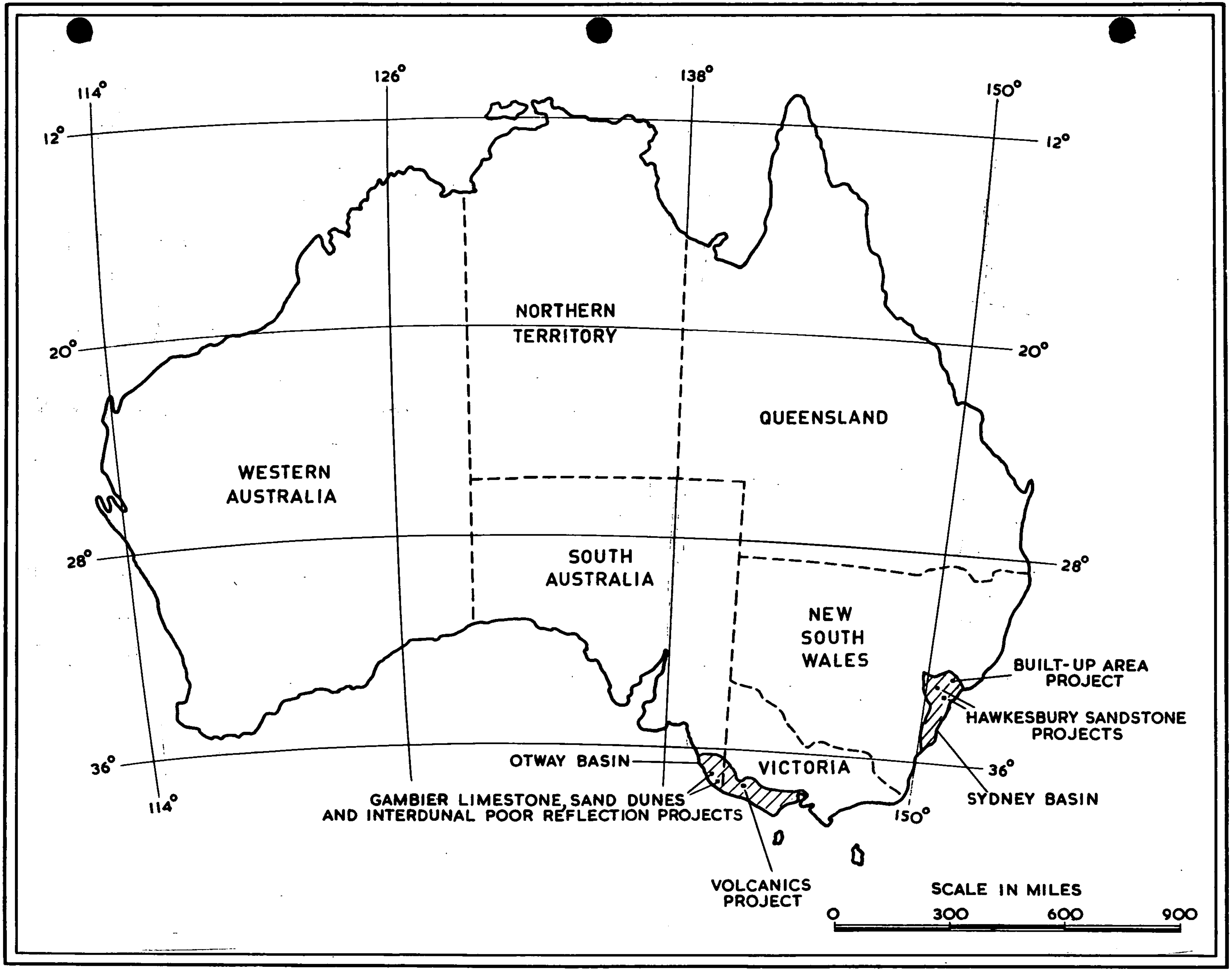


114°
126°
138°
150°
12°
12°
20°
20°
28°
28°
36°
36°
114°
150°
NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
VICTORIA
BUILT-UP AREA PROJECT
HAWKESBURY SANDSTONE PROJECTS
SYDNEY BASIN
OTWAY BASIN
GAMBIER LIMESTONE, SAND DUNES AND INTERDUNAL POOR REFLECTION PROJECTS
VOLCANICS PROJECT
SCALE IN MILES
0
300
600
900

INTRODUCTION

The Vibroseis method of seismic exploration was first introduced into Australia during 1963.

In accordance with the programme for accelerated oil search, the Bureau of Mineral Resources employed a Vibroseis seismic party to demonstrate the performance of the method in various problem areas within the Otway and Sydney Basins, the locations of which are indicated on the regional map.

The Experimental Vibroseis Seismic Survey was conducted by Seismograph Service Limited, Party 243, on behalf of the Bureau of Mineral Resources, Geology and Geophysics during the period from 11th May to 3rd October, 1964.

The broad objective of the survey was to demonstrate the capabilities of the Vibroseis method in selected areas where previous conventional seismic surveys had experienced difficulties in obtaining results and where various seismic problems had been defined. The main aim of the survey was to obtain good quality results rather than a high production rate yielding poorer quality data. However, as a secondary objective, some short production traverses were recorded using the optimum field technique developed during the course of the survey for comparison with normal shot hole production techniques.

In the Otway Basin four areas were selected each with a distinctive terrain which creates a special seismic problem. These are reported on as separate projects as follows :-

(1) Volcanics Project - basalt covered areas within the Portland Sunklands.

(2) Gambier Limestone Project - areas of outcrop within the Gambier Sunklands.

(3) Sand Dunes Project - areas of sand cover within the Gambier Sunklands.

(4) Poor Reflection Area Project - an inter-dunal area within the Gambier Sunklands.

In the Sydney Basin, two projects were undertaken as follows :-

(1) Hawkesbury Sandstone Project - areas of outcrop of this formation.

(2) Built-Up Area Project - an area of heavy population.

In each case the particular locations of the Vibroseis traverses were selected on the basis of the availability of previous seismic data, well control, accessibility and pertinence to future oil prospecting proposals.

This report has been divided into two major sections to cover the work conducted in the Otway and the Sydney Basins. The report has been further sub-divided to cover in detail the work carried out on the four projects which comprise the Otway Basin section and on the two projects which comprise the Sydney Basin Section.

OTWAY BASIN

SYNOPSIS

The Experimental Vibroseis Survey in the Otway Basin was conducted by Seismograph Service Limited, Party 243 on behalf of the Bureau of Mineral Resources, Geology and Geophysics during the period of 11th May to 14th August, 1964.

The survey comprised four separate projects which were designated the Volcanics, Gambier Limestone, Sand Dunes and Inter-Dunal Poor Reflection Area Projects. Each project was designed to assess the Vibroseis method in an area where conventional shot hole methods had experienced difficulty in obtaining good quality seismic data.

The first 'Volcanics' Project was located in the Portland Sunklands area of South-West Victoria and occupied 33 working days during the period 11th May to 24th June, 1964. The seismic problem investigated during this project was that inherent to the presence of volcanics. Over the northern part of the Portland Sunklands, basalt layers form a screen through which it had been found difficult to transmit seismic energy to the geological section below.

During the course of the survey, a Vibroseis field technique was developed which proved capable of penetrating the known near surface basalt layers and provided reliable structural information on the deeper formations.

The remaining three projects within the Otway Basin were all located in the Gambier Sunklands area of south-eastern South Australia.

The Gambier Limestone Project occupied 27 working days during the period 25th June to 30th July, 1964. This project was designed to assess the Vibroseis method on areas outcropping Gambier Limestone; the problems associated with this limestone were considered to be due mainly to its extremely cavernous nature.

The Vibroseis experimental results show that reliable seismic data can be obtained on these outcrops and reflections were recorded down to depths of 13,000 feet.

The Sand Dunes Project was completed in 8 working days during the period between 31st July and 10th August and on 14th August, 1964. This project combined surveys on two typical types of sand area encountered within the Gambier Sunklands. The first was characterised by a gently undulating sand sheet cover and the second by low ranges of recent coastal and consolidated fossil dunes. The seismic problem in these areas had been considered to be due largely to high energy transmission losses within the surface sand layers.

On the sand traverse, the Vibroseis results were satisfactory and showed equivalent reflection quality and penetration to that obtained on another traverse surveyed in the same locality where no surface sand was present. However the results on the fossil sand dune were of generally poor quality and this problem was not satisfactorily solved during the survey.

The final project of the Otway Basin Survey consisted of a short traverse sited in an area between the sand dune ridges which cover a large part of the north-western region of the Gambier Sunklands. This Inter-Dunal Poor Reflection Area Project occupied only three working days and was completed during the period 11th-13th August, 1964.

Previous conventional surveys had produced poor quality data, although quite simple field techniques had yielded good data further north on similar surface conditions. The Vibroseis Survey yielded reflection results which were generally fair to poor but the survey was too restricted for valid conclusions on the comparison.

GEOLOGY AND PREVIOUS GEOPHYSICS

Geology.

The Otway Basin extends along the south-west coast of Victoria to the west of the Barrabool Hills and into south-eastern South Australia as far north as Kingston. It consists of Tertiary and Mesozoic sediments with widely varying lithologies and of largely undetermined thickness. The surface geology is obscured in wide areas by recent sands, dunes and swamps but where exposed is seen to be mainly Tertiary volcanics and marine limestones. Knowledge of the early sedimentation in the basin is therefore dependant on geophysical work and stratigraphic drilling.

The Otway Basin is separated from the Murray Basin by the Padthaway Horst and is itself divided into three sub-basins by sub-surface ridges. In the west are the Gambier Sunklands, bounded by the Padthaway Horst, the Kanawincka Fault and the Dartmoor Ridge. The Portland Sunklands occupy the central portion of the basin and are separated from the Torquay Embayment in the east by a sub-surface ridge between the Otway Ranges and the Barrabool Hills.

A series of faults run parallel to the coast, in contrast to the north-south trend of the faults seen in the Palaeozoic formation exposed further to the north. The faults are seen on the surface in the Gambier Sunklands but not in the Portland Sunklands where they affect only the pre-Tertiary sediments. The latter thickens towards the south which is the downthrown direction of the faults. The main basement movement occurred at the end of the lower Cretaceous; some movements, however, continued into the Tertiary and probably culminated in the Tertiary volcanic activity.

In the Gambier Sunklands the surface cover consists of sands and alluvium with some exposed sediments in the south and west. The latter comprise limestones and marls above quartzose and conglomeratic sandstones and include the Oligocene marine Gambier Limestone.

In the area of interest in the Portland Basin, around the north and east of the Tyrrendarra Embayment, basalt layers cover the surface together with extensive beds of tuff and scoria. These are underlain by alluvium and Tertiary sediments consisting of limestones and marls above quartzose and conglomeratic sandstones; further basalt layers probably occur within the sequence.

The Upper Cretaceous is represented by glauconitic sands and carbonaceous shales with basal limestones which grade into mudstones, sandstones, and greywackes of the Lower Cretaceous. Beneath the latter lies the important Otway-Merino Group of coarse sandstones which has not however been penetrated in bores sunk within the Gambier Sunklands. In the Portland sub-basin, the Otway Group has been found to be 3040 feet thick in the Pretty Hills No. 1 bore. Below this group are further sands forming the local base of the Mosozoic; they probably rest on Cambrian diabase.

The main petroleum source rock is the marine Upper Cretaceous Belfast Mudstone which thickens considerably in the Gambier Sunklands where the Mount Salt No. 1 bore was terminated in this formation at 10,044 feet. Coastal bitumen seepages give some indications of the presence of hydrocarbons in sub-marine areas of the basin. The Otway Group has the lithology of a good reservoir rock and fluorescence has been detected in it in the Flaxmans Hill No. 1 bore.

Previous Geophysics

Magnetic - No regular coverage has been made of the Otway Basin. Traverses have been run by the Bureau of Mineral Resources aircraft between Melbourne and Adelaide which indicate that the major anomalies recorded in the central part of the basin are associated with volcanic activity. The Zinc Corporation Ltd. conducted an aeromagnetic survey of the Portland Sunklands and experienced similar difficulty in Interpreting the results.

In the Gambier Sunklands, the South Australian Mines Department have carried out a magnetic survey which shows the northern margin of the sub-basin with strong magnetic relief; however, elsewhere, the magnetic profiles were flat except in areas probably affected by volcanic activity.

The magnetic method is therefore not considered to be a very effective geophysical method within the Otway Basin.

Gravity - Gravity surveys in the Otway Basin have been conducted by the Bureau of Mineral Resources, the South Australian Mines Department and Frome - Broken Hill Co. Pty. Ltd. The coverage is mainly along roads and is densest in the coastal area. Bouguer anomaly contours are well controlled near the coast but speculative to the north.

The gravity work has generally been unsuccessful in delineating the Mesozoic and Tertiary structures particularly in the areas of volcanic cover in south-east Victoria. In the central part of the basin, the results suggest a thick sedimentary section as far north as Hamilton and east to Hawkesdale.

In the Gambier Sunklands, the results are anomalous with respect to the known areas of great thickness of sediments and it has been suggested that this is due to the intrusion of volcanics at depth.

In general, gravity surveys in the Otway Basin have not been successful in defining sedimentary structures.

Seismic - Seismic surveys have been conducted within the Otway Basin since 1956 by the Bureau of Mineral Resources, the South Australian Mines Department and contract crews employed by the various lease holders. A total of 2 700 miles of traverse had been shot using conventional shot methods in the coastal areas of the Portland Sunklands, in the Gambier Sunklands, and in the offshore areas.

The offshore seismic work gave good results and shows deep structures trending parallel to the coast overlain by a series of gentler folds which trend in an E. N. E. direction to the Otway Ranges.

Within the Portland Sunklands in the areas with no basalt cover, fair quality results have been obtained using relatively simple field techniques. However in areas on or bordering the basalt cover the reflection quality has generally been very poor.

The most successful conventional technique in the basalt areas employed a six fold common depth point method; with this method encouraging results were obtained but traversing was generally slow and the drilling difficult and costly.

In the Gambier Sunklands, the previous conventional seismic surveys have normally utilised simple reconnaisance techniques and little experimentation has been conducted to define the seismic problems. In many areas, fair results have been obtained but when recording on Gambier Limestone or on Sand Dunes, the seismic results have been poor.

Details of the reports from which this Section has been compiled are given in the Acknowledgements Section.

PART I. VOLCANICS

Objectives

The overall objective of the Volcanics Project was to assess the Vibroseis method on the basalt cover of the Portland Sunklands where previously conventional shot hole methods had produced poor results.

The survey consisted of three parts, Volcanics 1, 2 and 3. The Locations were selected on the basis of availability of previous seismic data, well control, accessibility and pertinence to future oil prospecting proposals.

Volcanics I. This part of the project was designed as an initial test of the Vibroseis method in an area where the basalt cover is absent and good conventional seismic data had been obtained. The location selected was in the immediate vicinity of Pretty Hills No. 1. bore; a continuous velocity log and a synthetic seismogram from this bore were available.

Volcanics II. This part of the project comprised the major part of the survey and was located in an area of basalt cover where previous conventional seismic work had given extremely poor results. All the detailed experimentation was carried out in this area with the objective of establishing the optimum field technique.

Volcanics III. This part of the project was conducted with the objective of testing the technique developed in the Volcanics II section. The location selected was in another region of basalt cover within the Portland Sunklands and lay approximately 20 miles to the west of the Volcanics II location.

Programme

Volcanics I. The traverse was situated two miles to the South of Orford on the Port Fairy-Macarthur road in the Shire of Belfast. Approximately 2 miles of line was vibrated near the Pretty Hills No. 1. bore. The line was firstly traversed using a transposed method which occupied two days, a further two days were then worked retraversing the line using a ten fold common depth point technique.

Volcanics II. The traverse was conducted approximately 12 miles south of the township of Hamilton on the Mount Napier road in the Shire of Dundas. The major part of the experimental work was performed at the northern end of the traverse where the basalt cover was considered to be thickest. A total of 18 and a half days were occupied on the detailed experimentation, 5 and a half days on transposed production recording and two days on retraversing a part of the line using a 10-fold common depth point technique.

Volcanics III. The traverse was located about 6 miles to the north-east of Heywood on the road between Heywood and Hamilton in the Shire of Portland. The only experimental work carried out on this second area of basalt cover was a noise spread and this was followed by 2 and a half days of transposed production recording and 1 and a half days of 10-fold common depth point recording using the methods previously developed as a result of the experimental programme of the Volcanics II part of the project.

Topography and Survey

Volcanics I and II. These traverses lay in country with similar topographical conditions. The regions consist of gently undulating grassland divided into paddocks. The land is used mainly for rearing cattle and sheep. Although the traverses were surveyed along the road some of the geophone patterns, due to their width encroached upon the adjacent private land . Frequently throughout the course of this part of the survey, attention had to be given to prevent damage to cables and geophones by livestock.

Volcanics III . This traverse lay in more rapidly undulating terrain and was heavily wooded on either side of the road.

The spreads for the three traverses were chained and the distances checked by tacheometry. At Volcanics I only 1320 ft. spreads were laid but at Volcanics II and III both 1320 and 880 feet spreads were surveyed. The relative positions of the two series of vibrator points are shown on the V.P. location maps on Enclosure No. 2. The vibrator point locations were plotted on the maps with reference to 1 inch to 1 mile maps surveyed and compiled by the Department of Lands and Survey, Victoria. Vertical control of the survey was carried out using a Watt's No. 1. Microptic Theodolite. The level traverses were checked by taking reverse repeat readings.

Volcanics I. A starting elevation of 191 feet above sea level was obtained from the Pretty Hills triangulation point. Using this reference a traverse was made to the Pretty Hills bore where the elevation was found to be 180.5 feet above sea level. The elevation varied between 223 feet at the northern end and 157 feet at the south.

Volcanics II. The starting elevation used was 694 feet. This level was taken from the conventional shot point No. 3650. The elevations varied between 696 feet in the north and 597 feet at the southern end of the traverse.

Volcanics III. The starting elevation was taken from the conventional shot point No. 3846 which was given as 439 feet above sea level. The elevations varied between 381 and 455 feet on this traverse.

Permanent markers were placed at the following locations:-

Volcanics I	V.P.s	100 and 95
Volcanics II	V.P.s	200, 184 and 165
Volcanics III	V.P.s	200 and 185.

The markers consist of a steel picket bearing an aluminium tag on which is inscribed the project number, the line number, the vibrator point number and the date.

Computing

For the Volcanics I traverse the elevation datum used was Mean Sea Level. To minimise possible errors introduced by large static corrections the elevation datum was raised for traverse Volcanics II to 500 feet above Mean Sea Level and for traverse Volcanics III to 300 feet above Mean Sea Level.

Datum corrections were computed at each V.P. in accordance with the formula :-

$$\frac{Ev + Eg - 2dw}{Ve} + \frac{2dw}{Vw}$$

Where Ev and Eg are the elevations above datum at the vibrator and geophone positions.

Ve = Elevation Velocity

Vw = Weathering Velocity

dw = Depth of Weathering.

The elevation and weathering velocities used for all the Volcanics traverses were 6000 ft/sec and 2000 ft/sec respectively. These were taken from determinations on previous conventional lines in the near vicinity.

The thickness of the weathering layer was assumed constant for the Volcanics I traverse, at 30 feet, and also for the Volcanics II traverse, at 25 feet. For the Volcanics III traverse the values used for the depth of weathering at each V.P. were derived from the weathering profile previously drawn up by the conventional seismic party. These values varied between 15 and 35 feet.

The velocity function used to correct the normal move-out curvature of the reflection was derived from the Sonic Log of Pretty Hills No. 1. bore. This velocity function is presented on Enclosure No. 11 as an

Average Velocity-Depth plot.

A velocity profile was vibrated to assess more clearly the applicability of the velocity function. A common profile, 180N of the Volcanics II traverse, was vibrated from four different offsets covering the distance from 0 to 2640 ft. The results are shown both as a Variable Area presentation and as a Time^2 - Distance^2 plot. (Enclosure Nos. 7 and 8).

A tabulation of the average velocities obtained are shown below, compared with the values obtained from the Pretty Hills No. 1. Sonic Log and indicates a higher average velocity in the section of the Volcanics II traverse.

Two-Way Time	Velocity from Log	Velocity from $T^2 - X^2$
.700 sec	7200 ft/sec	7700 ft/sec
.900 sec	7600 ft/sec	8000 ft/sec
1.200 sec	8200 ft/sec	9100 ft/sec

Recording

Introduction The overall objective of the Volcanics Project was to assess the Vibroseis method on basalt cover.

As a result of the experimental work carried out, the following transposed field technique was developed on the Volcanics II traverse as the apparent optimum for recording in areas of basalt cover :-

Geophone pattern	-	400 geophones on a rectangle of length 400 feet and width 200 feet.
Vibrator pattern	-	3 vibrators in-line over a length of 400 feet.
No. of sweeps	-	10 per trace.
Trace interval	-	88 feet
Offset distance	-	880-1760 feet
Sweep frequency	-	20-57 cycles per second.

The project comprised three parts, Volcanics I, II, and III and the experimental recording procedures

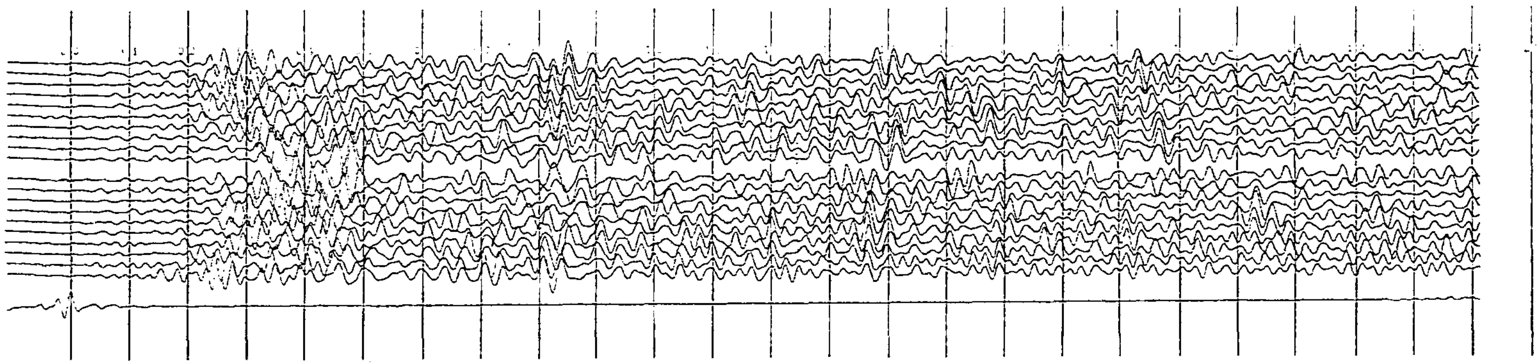


Fig. A. Vibrators on grass verge.

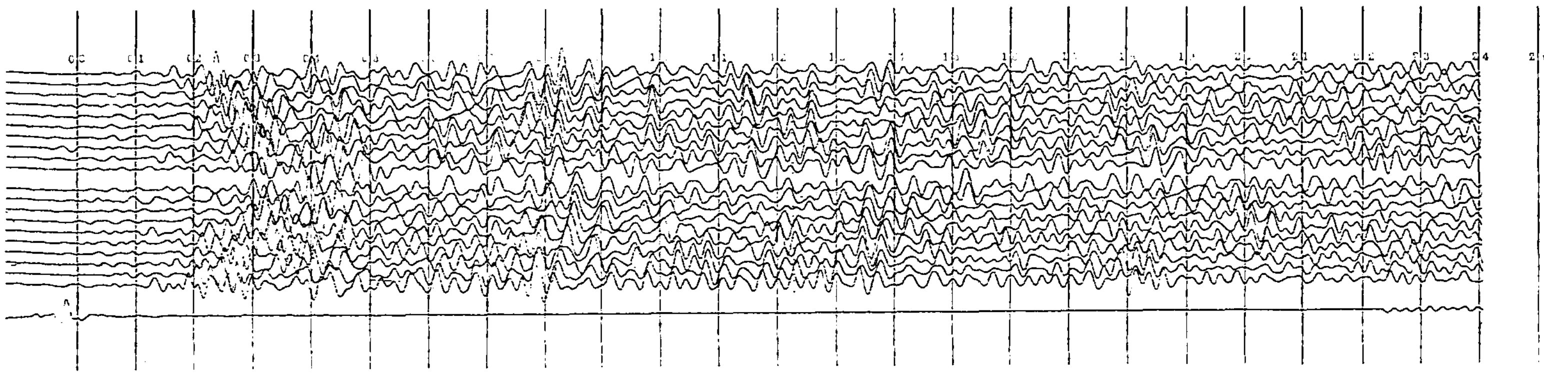


Fig. B. Vibrators on bitumen road surface.

PLATE (VOLC.) I.

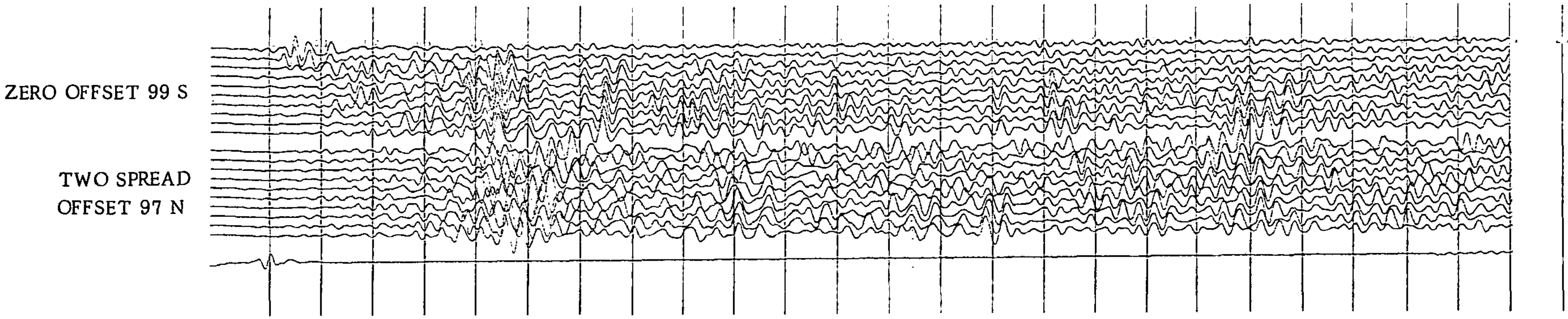


Fig. A.

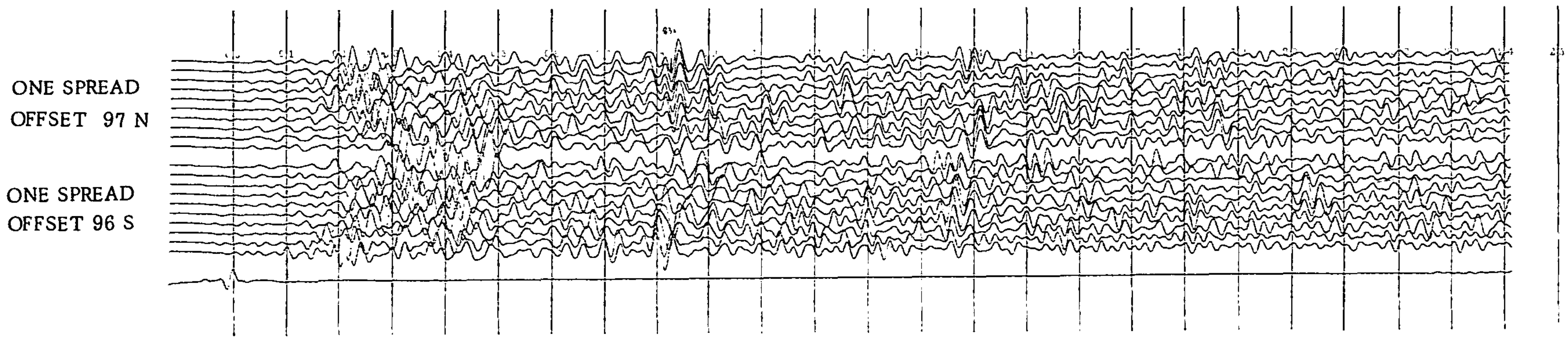


Fig. B.

PLATE (VOLC.) 2.

for each part are discussed separately in the following sections.

Volcanics I. The object was to obtain results for comparison with previous conventional work in an area where a 'window' in the basalt occurred and to obtain a comparison between two different methods of recording, namely the 'transposed' and 'common depth point' or 'vertical stacking' techniques.

Parameter Comparisons. Several minor comparisons were made during the recording of the transposed traverse; Profiles 96 South and 97 North were recorded twice, firstly with the vibrators operating on the grass verge at the side of the road and secondly on the bitumen road surface. The comparison of the two corrected field tape playback records is shown on Plate (Volc.) I. Fig. A. shows the first case and Fig. B. the second, no significant difference is evident between the two records. Profile 97 N was again produced using a two spread offset. This profile is shown on the lower half of Plate (Volc.) 2. Fig. A. and the comparison one spread offset (1320-2640 ft.) is shown on the upper half of Fig. B. The deep reflection at a time of approximately 1.8 seconds is shown to be of higher quality on Fig. A. whereas the shallow information is considerably attenuated due to the effect of the vibrator and geophone pattern spatial filters. The reflection at 0.9 seconds shows a marked absence of the higher frequency components on the longer offset record.

Field techniques. The resulting variable area sections produced from the Volcanics I traverse are shown as Enclosure Nos. 3 and 4 for the transposed and common depth point methods respectively.

The field technique employed for the transposed section was :-

Geophone pattern	-	400 geophones in a rectangular pattern of length 400 feet and width 200 feet
Vibrator pattern	-	3 Vibrators spaced at 30 feet intervals over a length of 400 feet
No. of Sweeps	-	10 per trace
Trace interval	-	132 feet
Offset distance	-	1320 - 2640 feet
Sweep frequency	-	14 - 57 cycles per second.

and for the common depth point recording the field technique was :-

Geophone pattern	-	40 geophones in line over a distance of 264 feet.
Vibrator pattern	-	3 or 2 vibrators located side by side covering a distance of 264 feet.
No. of sweeps	-	10 per trace
Trace interval	-	132 feet
Offset distance	-	1320 feet for the near trace sample and 3960 feet for the outer trace sample.
Sweep frequency	-	14 - 57 cycles per second.

The transposed technique does not possess the definition and continuity of the reflections that appear when the common depth point method is used. The poor quality shallow reflection at approximately 0.5 secs on the transposed section is not obvious on the common depth point section. This is probably partially due to poor addition of the common depth point samples caused by limitations of the spread corrector action on the outer traces at the larger offsets which would result in under correction and which is accentuated by the low average velocity. The reduction of the pattern lengths from 400 to 264 feet for the common depth point technique was made in order to preserve the shallow data to be recorded whilst employing the larger offsets inherent to this method.

The criteria for establishing the pattern length that can be used for any reflector are firstly, the offset distance, secondly, the average velocity to the reflector and thirdly, the wavelength ($\frac{\text{velocity}}{\text{frequency}}$) of the reflection.

Using the velocity function established from the Pretty Hills No. 1. Well Log the maximum permissable pattern length for a time of 0.5 seconds, an offset distance of 1980 feet (the distance to the centre of the spread) and a frequency of 35 cycles per second (the centre frequency of the sweep spectrum f_c) is given by the formula :-

$$L = \frac{Va}{2f_c \cos\theta}$$

$$L = 200 \text{ feet.}$$

Where Va is the average velocity, $\tan\theta = \frac{2Z}{X}$ (Z = depth and X = offset distance.)

The most striking improvement using the common depth point method is noted in the quality of the deeper reflections and is attributed, in this particular area, to the addition of many samples which originate at different vibrator and geophone locations and hence smooth out any local surface or near surface irregularities.

Volcanics II This part of the Volcanics project comprised the main experimental programme.

Noise Test The programme was commenced with a noise spread using the following in-line method :-

Geophone pattern	-	10 geophones in a group 0 feet in line by 10 feet transverse.
Vibrator pattern	-	Zero - vibrated from one location.
No. of sweeps	-	Varied from one to ten.
Trace interval	-	20 feet.
Offset distance	-	400 feet to nearest trace. 3980 feet to outside geophone.
Sweep frequency	-	10 - 113 cycles per second.

The in-line method, which uses a common vibrating point, was adopted to eliminate any variations in the seismic energy input due to variations in the near surface conditions.

In an attempt to derive the relative amplitudes of the noise events from recordings made with similar amplitudes at the different offset distances employed the following procedure for weighting the recorded signals was adopted :-

The signal level of the inner trace of the first twenty stations, ranging from 400 feet to 780 feet from the vibrator was adjusted so that the recording tape was fully modulated by the signal from the nearest geophone station. A recording was then made and it was checked that the signal level on transcription never exceeded full modulation. The remainder of the amplifiers were then set at the same gain as that connected to geophones nearest to the vibrator.

The first twenty traces were recorded using one sweep. This field tape was then transcribed, without suppression, on to the correlator tape where it was recorded on one decatrack position only.

The second set-up consisted of the second twenty stations ranging from 800 feet to 1180 feet. This was recorded using the same gain as the first but two sweeps were employed and added together using the field tape decatrack. A check was made again that the added transcribed signal nowhere overmodulated the correlation tape and the combined signal was transcribed on to two decatracks of the correlator tape.

The succeeding recordings were made by maintaining the original amplifier gain settings and increasing the number of sweeps by one for each successive set-up. The number of decatrack positions modulated on the correlator tape was increased by one for each set-up.

This method was developed largely on the presupposition that the energy fall off would be roughly inversely proportional to the square of the distance from the source.

The recording method described above gives a weighting to the signals which is proportional to the square of the distance from the vibrator. Hence, ideally each correlator tape should present a signal of the same order of magnitude to the correlator.

This however, did not occur in practice and it was found that the energy decay was greater than anticipated and the recording level became too low. In order to compensate for this, the amplifier gains were increased by a factor which suited the modulation criteria for both recording and transcription processes. The set-up on which the record gains were increased was repeated with the new gain, in order to check the calibration.

The record amplifier gains were increased when the signal level fell to approximately 10% of full modulation, and also whenever the signal to random noise level approached 1:1

In order to maintain the linearity of the system, the following correlation and playback method was used.

From the suite of correlator tapes for a noise spread, the tape having the highest amplitude was selected and the correlator gain adjusted so that the maximum of this signal was just below the full modulation level on the correlator tape.

The remainder of the tapes were then correlated using this gain setting and played onto teledeltos records with A.V.C. off. If the level of a record became too low to permit accurate amplitude measurements, the pen drive was increased and the tape replayed in order to provide a calibration and so obtain a new 'weighting factor'.

To consider a practical example, the 'weighting factor' for a particular record was established thus :-
The fifth set-up consisting of 20 traces, 20 feet apart, ranging from 2000 feet offset to 2380 feet was

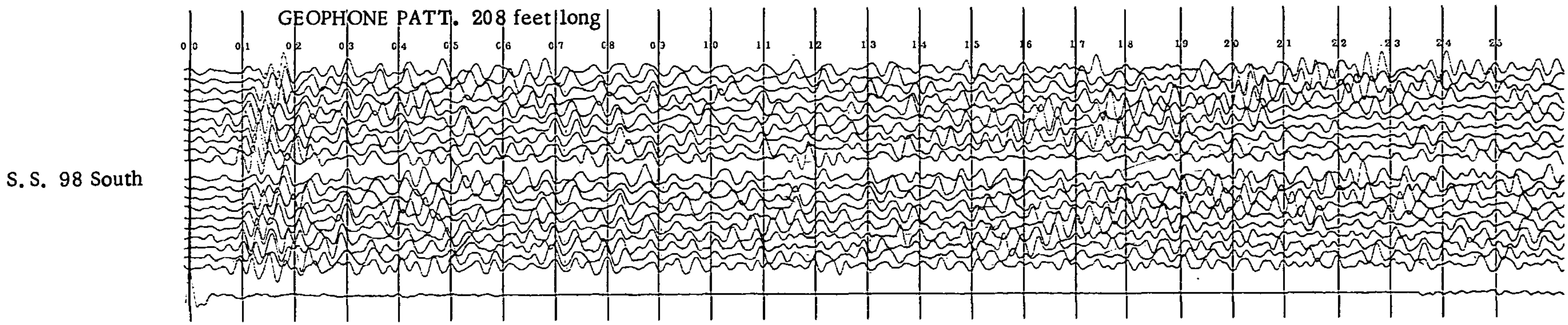


Fig. A. Field tape No. 3452 (dynamically corrected).

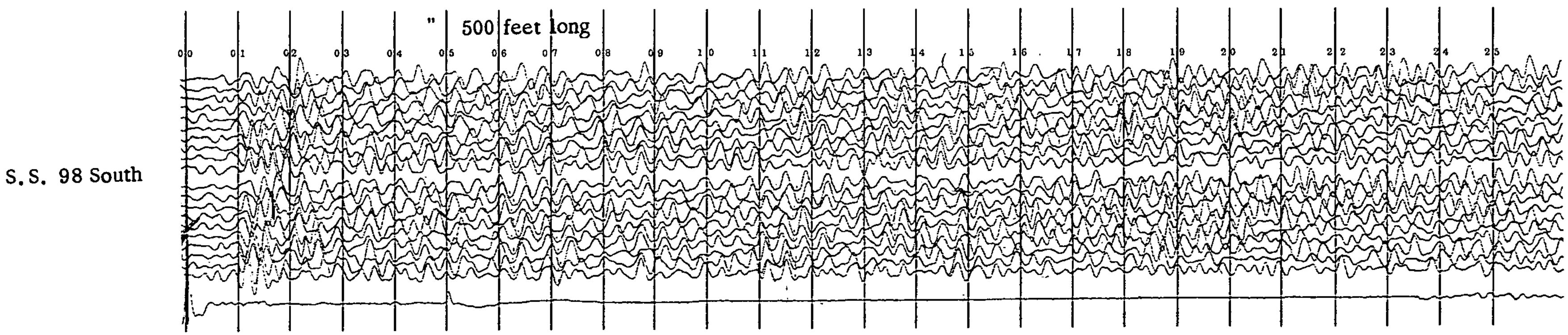


Fig. B. Field tape No. 3461 (dynamically corrected).

recorded with five sweeps and transcribed onto five decatracks. Then because the record level in the field had fallen to approximately 10% of full modulation, the Observer had increased the amplifier gains by a factor of three. In this case the 'weighting factor' would be 5 x 5 x 3 = 75.

The amplitude of an event on the A.V.C. off record was measured, averaged over ten traces (offset distance 400 feet to 780 feet) and expressed as a fraction of the amplitude of the nearest trace to the vibrator. This fraction was then divided by the 'weighting factor' to give the relationship that existed in the ground.

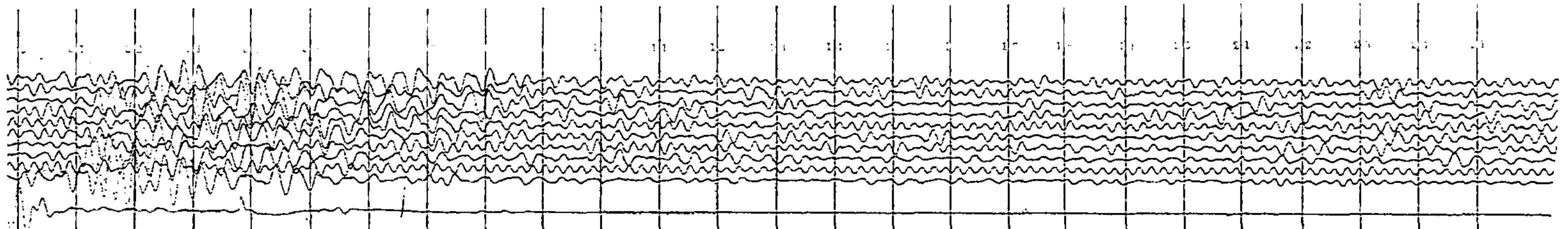
All usable alignments were treated in this way and their fractional ratios expressed logarithmically and plotted in dbs. against the frequency and wave number for each event. These plots together with the Variable Area playbacks are included as enclosures to this report. The principal velocities recorded were 13,300 and 6000 - 6500 feet per second; the former corresponds to basalt layer and the results indicate that this interference has a wavelength of 400 - 450 feet at the observed frequency of 30 cycles per second.

In order to account for the improvement in record quality to the south of V.P. 185, a second noise spread was vibrated. The recording procedure was the same as that described above for the first noise spread. The Variable Area presentation is Enclosure No. 15. A similar noise pattern is shown to that on the first noise spread but the noise with a velocity of between 6000 and 6500 feet per second is only present in the first case. In the second case however, some reflected energy is apparent at a time of 0.9 seconds. It is concluded therefore that the reflecting conditions improved in this part of the line and that no radical change exists in the coherent noise itself.

Part of the second noise spread was repeated using the transposed method. The Variable Area playback of this part of the noise spread is shown on Enclosure No. 18. Both refracted and reflected events have more energy relative to the ambient noise in this case. This is probably due to the use of fifty geophones an increase of five times over the number used for the in-line noise spread.

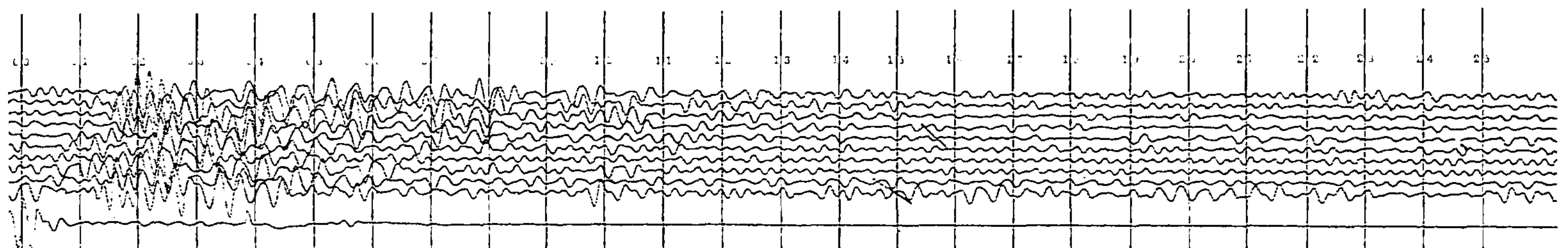
Parameter comparisons. Comparisons were initially made between different vibrator and geophone pattern lengths. Plate (Volc.) 3 shows the four records obtained with geophone pattern lengths of 208, 415, 500 and 600 feet in combinations with a vibrator pattern length of 400 feet. As the pattern length is increased a slight improvement can be seen in the event at 0.6 seconds. The high velocity 'first break' energy is not greatly affected by the increasing geophone pattern lengths but the air wave, which is apparent between 1.5 and 2.0 seconds suffers a considerable degree of attenuation between the 200 and 600 feet pattern lengths. Curves showing the theoretical attenuation for the pattern length employed are included as an enclosure.

197 South



10 sweep per trace. Fig. A. Field tape No. 3468. (uncorrected AVC. OFF.)

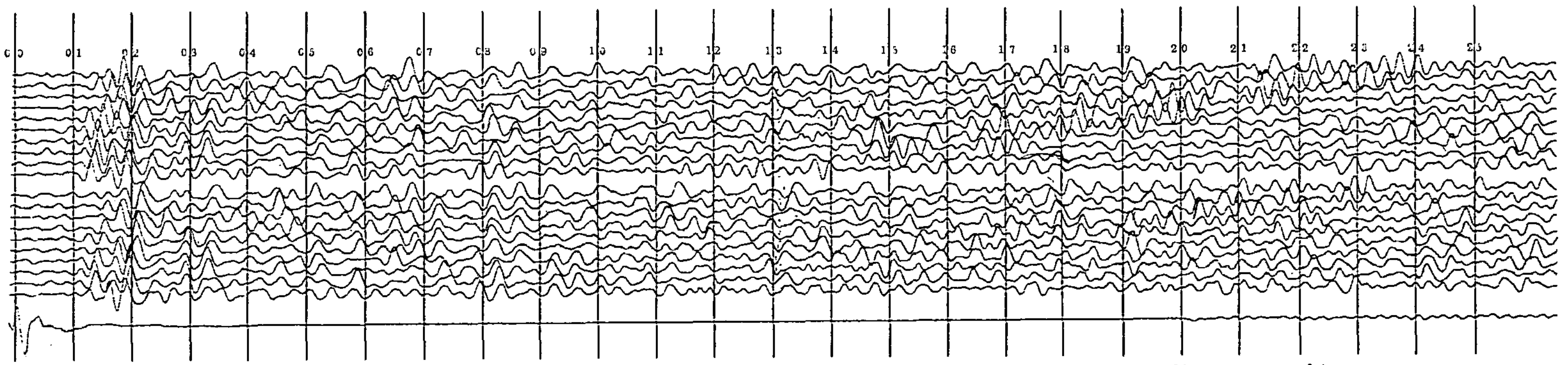
197 South



20 sweep per trace. Fig. B. Field tape No. 3467. (uncorrected AVC. OFF.)

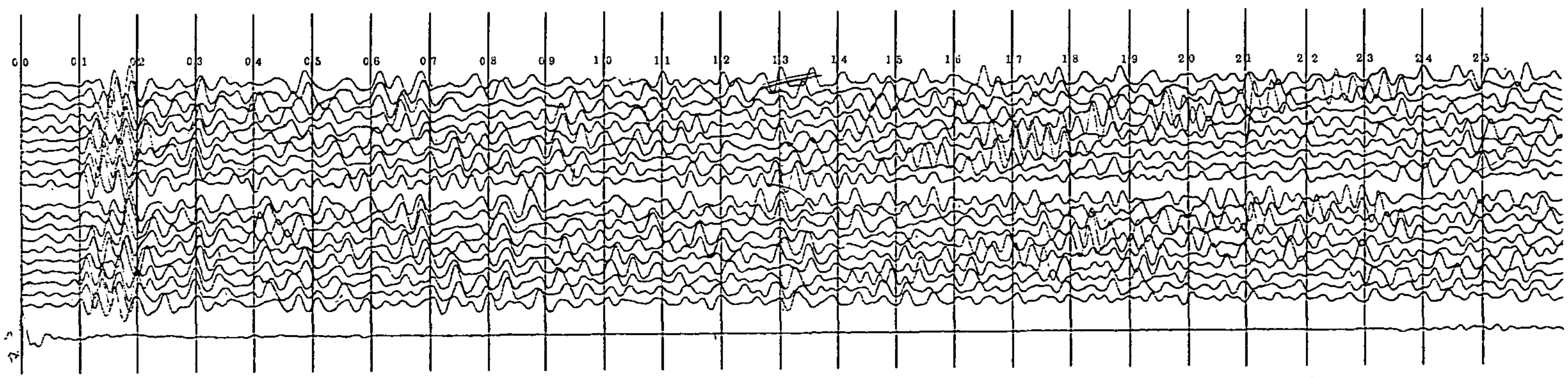
PLATE VOLC. 4.

98 South



10 - 80 c. p. s. sweep. Fig. C. Field tape No. 3700. (dynamically corrected)

98 South



14 - 57 sweep. Fig. D. Field tape No. 3451. (dynamically corrected)

PLATE VOLC. 5.

From these comparisons and succeeding results a 400 feet pattern length was considered to be the best. This was chosen as a compromise between the longer patterns necessary to attenuate the coherent noise and the shorter which apply only limited attenuation to the reflected signals due to their spatial filtering.

Subsequently part of the traverse from V.P. 195 to 190 was vibrated using patterns of only 200 feet in length and the record quality obtained was compatible with that using 400 feet patterns. It is thought that in this region the signal to the coherent noise ratio was sufficiently high to permit the use of smaller patterns although they do not appreciably attenuate the coherent noise.

A comparison between 10 and 20 sweeps per trace is shown on Plate (Volc.) 4 Fig. A. shows Profile 197 south (field tape No. 3468) recorded with 10 sweeps per trace and Fig. B. (field tape No. 3467) with 20, both records are played with A.V.C. off so that the signal to random noise ratio is preserved. Although there is little difference in the overall record quality, this comparison shows an improvement in the signal to random noise ratio in Fig. B. Theoretically the improvement should be by a factor of 1.4 . The predominant noise on both records is 50 cycles per second high line pick up.

A sweep frequency comparison is shown on Plate (Volc.) 5 between Fig. C. (10 - 80 c.p.s.) and Fig. D. (14 - 57 c.p.s.) The best reflection evident on the lower half of Fig. D. is at a time of approximately 0.8 seconds and its predominant frequency lies between 25 and 30 c.p.s. By using a sweep whose spectrum contains more energy at this frequency it can be seen, in Fig. D. that the reflection quality is improved. The lower halves of both figs. were vibrated using 415 feet pattern lengths, however the upper profiles, which employed a geophone pattern length of 208 feet, show that little improvement can be obtained by changing the sweep fequency when the pattern dimensions differ greatly from the optimum.

Succeeding sweep frequency comparisons showed marginal improvements using both 20-57 and 28-57 cycles per second. For the production the 20-57 cycles per second sweep was considered to be the optimum.

Comparisons were made to produce sub-surface Profile 180 N from offset distance of 0-880, 880-1760, 1760-2640 and 2640-3520 feet; the results are presented on the variable area section Enclosure No. 7 and demonstrate that the shallow reflection quality is optimum at the offset of 880-1760 feet.

On Profile 180 N a heavy transposed technique of 50 sweeps per trace into a geophone pattern containing 800 geophones was compared with the optimum transposed production technique to investigate

FIG. A. Field tape 4566

193 South
In Line
200 ft.
Patterns

193 South
Transposed
200 ft.
Patterns

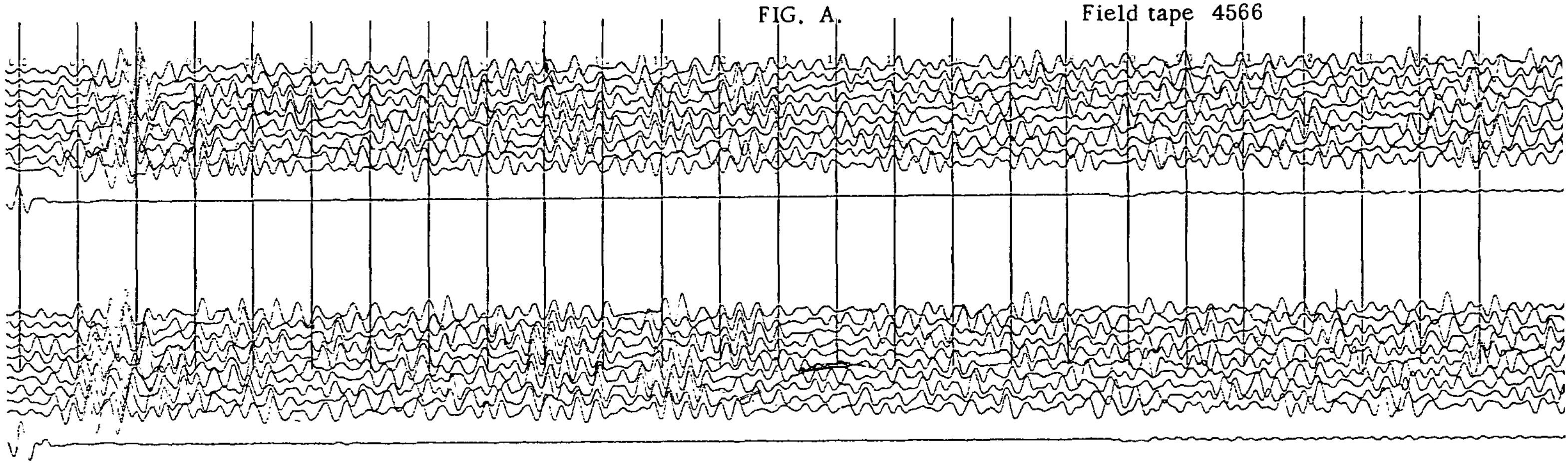


FIG. B. Field tape 4564

FIG. C. Field tape 4557

UP
DIP
194 North

DOWN
DIP
194 North

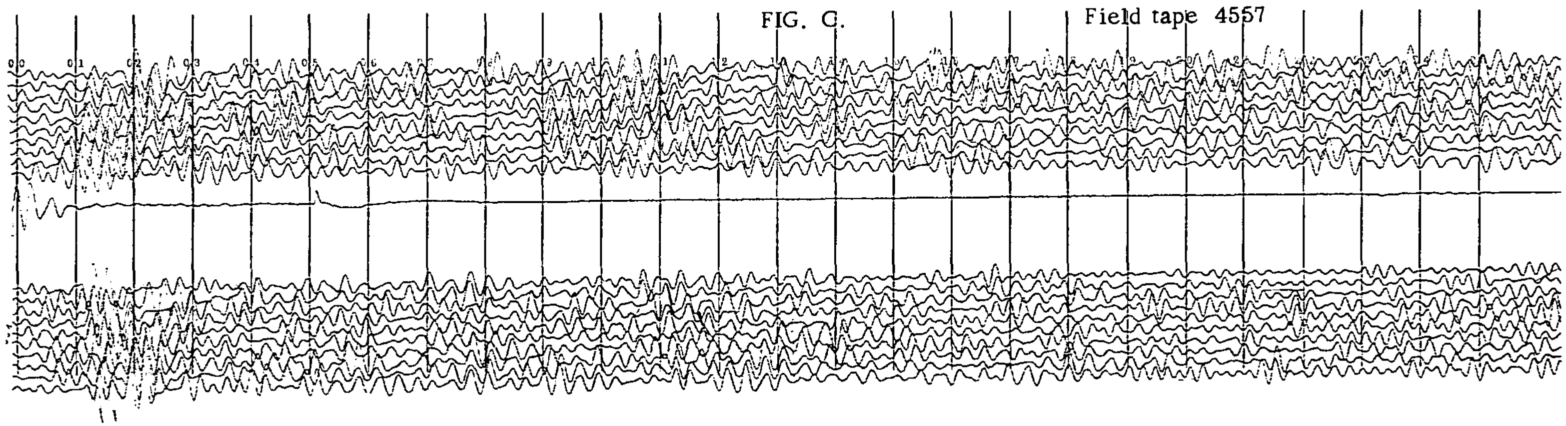


FIG. D. Field tape 4561

PLATE VOLC. 6. (All records dynamically corrected) whether any significant reflections could be obtained at depth with a considerable increase in the field effort. The results show an increase in the seismic energy over the random noise with the heavier effort but no additional reflection alignments were evident.

A comparison between the in-line and transposed methods was obtained on Profile 193 south. This is shown on Plate (Volc. 6) where Fig. A. shows the record obtained using the in-line method and Fig. B. the transposed. The reflected energy between 0.8 and 1.2 seconds has a better signal to noise ratio on Fig. B. however the transposed record was made by compositing 20 sweeps from 3 vibrators into 400 geophones thus giving a total of 24,000 ray paths per trace, but the in-line method composited 40 sweeps from 3 vibrators into 40 geophones giving only 4800 ray paths per trace. It is thought therefore that the in-line method could be considered as a production technique in this area for reconnaisance work but where the higher record quality is required for detail work the transposed method would probably have to be used except when the ambient random noise was extremely low.

Several profiles were vibrated using the in-line method in order to establish that its application was not local. During this work it was noticed that profiles vibrated 'down dip', that is where the effect of a dipping reflection is to lower the apparent velocity of a reflection, were considerably lower in quality than those recorded in the opposite direction. This effect is due to the normal move out cancellation of the geophone and vibrator patterns. An example of the difference in quality is shown on Plate (Volc.) 6, (Figs. C and D). The application of the technique of unidirectional recording, for this particular problem, requires previous knowledge of the direction and the degree of dip and is therefore not considered as a practical production method. However the comparison serves to demonstrate the effect of normal move out cancellation on energy arriving from a dipping reflector.

Field techniques. The sub-surface profiles recorded for all work on the Volcanics II project are shown on the diagram of field techniques, Enclosure No. 23. The traverse was composed of two series of vibrator points, the first, commencing at V.P. 99 in the north and descending to the south, used a trace interval of 132 feet and hence a distance between vibrator points of 1320 feet. The second series, commencing at V.P. 200 in the north and also descending to the south, used a trace interval of 88 feet and a vibrator point distance of 880 feet.

From the results ultimately obtained it was obvious that the initial experimentation was made in an area of disturbed or faulted geological conditions. As a result some of the comparisons made yielded information on which it was difficult to base a conclusion.

The following field technique was developed as the apparent optimum :-

Geophone pattern	-	400 geophones in a rectangular pattern of length 400 feet and width 200 feet.
Vibrator pattern	-	3 vibrators spaced 133 feet apart in line over a length of 400 feet.
No. of sweeps	-	10 per trace
Trace interval	-	88 feet
Offset distance	-	880 - 1760 feet
Sweep frequency	-	20 - 57 cycles per second

This method was used from V.P. 180 to the southern end of the line at V.P. 164. Prior to this some production was made between V.P.s 190 and 180 using the same layout but 20 sweeps per trace. It was decided however that in view of the prevailing quiet ambient conditions the production technique could be changed and the number of sweeps reduced to 10 per trace.

A ten-fold common depth point method was used to revibrate the line from V.P. 188 to 182. The field method employed was :-

Geophone pattern	-	40 geophones in line over 264 feet
Vibrator pattern	-	2 vibrators spaced 132 feet apart in line over 264 feet
No. of sweeps	-	10 per trace
Trace interval	-	132 feet
Offset distance	-	660 - 3300 feet
Sweep frequency	-	20 - 57 cycles per second.

Volcanics III. The same techniques were used on this section of the project as on the transposed and common depth point production traverses of the Volcanics II section. The overall record quality is lower than that obtained on Volcanics II. This deterioration is attributed largely to the high random ambient noise produced by high winds and heavy traffic that existed during the recording of the traverse but disturbed sub-surface conditions are thought also to exist. The noise spread (Enclosure No. 19) shows less coherent noise than the previous traverse the most obvious features being the lack of persistance of the high velocity basalt refraction and the absence of the noise within the velocity range 4000 to 7000 feet per second. The events with a velocity of approximately 15,000 and 12,000 feet per second in the time range 0.5 to 0.9 seconds are thought to be due to reflected energy but, as indicated on the transposed section, are limited to only short segments and hence lend support to the theory that disturbed geological conditions also contribute to the poor record quality.

Results. The Volcanics project has shown that the basalt cover does not present a serious seismic problem. Although at the high velocity contrast interfaces of the basalt sheet there must be considerable energy loss nevertheless data was successfully recorded from beneath this near surface cover. The effect of the high velocity refractor attributed to the basalt layer is not detrimental to the record quality, at least in the areas surveyed. Although the wave length of this refracted energy at the basalt velocity is considerably longer than the patterns employed (energy at 25 cycles per second has a wavelength of approximately 500 feet) its amplitude is not sufficiently high to cause the reflected signal to lie outside the recording range of the magnetic tape. In the case of Volcanics III the energy from this refractor does not persist, at an observable level, beyond 1400 feet from the source.

Volcanics I. The sections showing the results are Enclosures 3 and 4. The basement reflector is well defined and appears at a time of 1.7 seconds at V.P. 97. This location is chosen for reference as it is the closest to the Pretty Hills No. 1. bore. By comparison with the synthetic seismogram of this bore the reflector at 0.76 seconds may be identified as originating within the Otway Merino Formation and above this at 0.58 seconds a horizon may be similarly identified.as originating within the Lower Wangerrip Group. An unconformity is evident between these two horizons. The Pretty Hills Sands reflector indicated on the Synthetic seismogram is evident on the Variable Area Section at a time of 1.36 seconds. The Sonic Log of the Pretty Hills bore indicates good reflecting conditions at the top of the Upper Wangerrip Group, however, strong reflections from this region are not apparent due to the spatial filtering of the geophone and vibrator patterns.

Volcanics II. The variable area section of this traverse is included as Enclosure No. 5.. At the northern end of the section, between V.P.s 199 and 196 the poorer results are probably due to disturbed geological conditions.

Between V.P.s 196 and 188 a small syncline is revealed whose axis lies at V.P. 193 and appears at a time of 1.1 seconds. From V.P. 188 to 183 the quality is poor although a low amplitude event provides continuity at a time of approximately 0.8 seconds. Between V.P.s 183 and 184 there is evidence of faulting and from this point to the south the record character changes and a high amplitude reflection can be followed which shows good continuity to the southernmost end of the section at V.P. 164. This event shows an anticlinal reversal centred at V.P. 167. A good character correlation can be made between this strong reflection and the basement reflection recorded on Volcanics I project, however, there is some evidence, particularly between V.P.s 169 and 165 that deeper events do exist. In view of this, it is suggested that the strong reflector recorded on this section may not represent the basement but may be due to old volcanic extrusions lying within the sedimentary section.

The Variable Area Section showing the results of the common depth point method is Enclosure No. 6. to this report. The horizontal scale is less for this section than for the transposed section (Enclosure No. 5.) and is increased by the ratio of the trace interval, i.e. 88 feet to 132 feet.

The common depth point method has produced an improvement in continuity between V.P.s 188 and 185. On the transposed section, between V.P.s 185 and 184 a possible fault zone is indicated and disturbed geological conditions to the south from V.P. 184 to V.P. 183. The common depth point method has not defined this zone as clearly as the transposed.

Volcanics III. The results are presented in variable area section form as Enclosure No. 9. At each end of the section the quality is good. An event, with reasonable continuity, is evident between V.P.s 199 and 192. Continuity is lost between V.P.s 192 and 187. At this point this horizon reappears showing strong south dip. Several shallower horizons exist but the results are less reliable than the deeper information.

The common depth point method, shown as Enclosure No. 10, has improved the continuity of the event at 0.6 seconds, at V.P. 94 to a point midway between V.P.s 92 and 93, at this point the continuity is broken. A continuous event showing south dip exists from V.P. 92 to the southern end of the section emerging at a time of 0.7 seconds.

A good correlation can be made between the interval time of the seismic reflections at 0.9 and 0.5 seconds at the northern end of the transposed section and the time interval between the primary reflection shown on the synthetic seismogram of Eumeralla No. 1 Bore at times of 0.4 and 0.8 seconds. This bore is situated about 20 miles south east of the traverse. The Vibroseis record section shows a deeper reflection at 1.3 seconds which should correspond to a bed within the Otway Group. However the synthetic seismogram at Eumeralla No. 1. also indicates the probability of first order surface multiples at this reflection time.

OTWAY BASIN

PART II GAMBIER LIMESTONE

Objectives

The objective was to assess the capabilities of the Vibroseis method on the cavernous, outcropping Gambier Limestone in the south-eastern region of the Gambier Sunklands, and to investigate the effect of this formation on the transmission of seismic energy.

The project consisted of two traverses Gambier Limestone II and III. The first of these was chosen for the detailed experimental work in view of the poor seismic data previously obtained in the vicinity of the Mount Salt No. 1. bore, which lies approximately 2 miles to the north of the traverse, and also in view of the highly cavernous nature of the exposed Gambier Limestone. At Mount Salt No. 1. the Gambier Limestone has a thickness of 530 feet.

The particular objective of Gambier Limestone III was to test the optimum technique developed for the Gambier Limestone II line in another area of limestone outcrop. The site selected was about thirty miles to the north of the Gambier Limestone II line. In this area, conventional records were available which showed fair reflection quality.

Programme.

The location of the two Gambier Limestone traverses are shown on the Locality Map, Enclosure No. 25, and in greater detail on the V.P. Location Maps Enclosure Nos. 26 and 40. Originally, Gambier Limestone I traverse was planned as a short line to assess the method prior to the main experimental programme. This was abandoned due to the suitability of the second traverse for the experiments and the initial assessment, but the original traverse numbers were maintained. In consequence only traverses II and III are referred to in this report.

Gambier Limestone II. The traverse was situated eleven miles to the south of Mount Gambier within the Hundred of MacDonnell on the Old Boundary Road which extends westwards from the main Mount Gambier to Port MacDonnell road. The Mount Salt No. 1. bore is located about three miles to the north-west of this traverse.

A total of twenty four days were occupied on this traverse; sixteen days on the detailed experimentation; six days on production recording using the transposed method and two days retraversing a portion of the line using a ten fold common depth point technique.

Gambier Limestone III. This traverse was sited about twelve miles to the north of Mount Gambier in the vicinity of Glencoe township and within the Hundred of Young, County Grey. The traverse extended along the Mount Gambier to Kalangadoo road.

A total of three days was worked on this traverse; two days on production recording using the same transposed technique as for the Gambier Limestone II traverse and one retraversing a portion of the line using a more rapid simpler transposed method.

Topography and Survey.

Gambier Limestone II. The traverse was situated in an area used mainly for grazing. A thin layer of soil covered most of the region but occasionally areas of exposed Gambier Limestone were evident. Low ridges of old sand dunes, in the immediate vicinity of the traverse, lie in an east-west direction and result in a gently undulating topography. The land is divided into paddocks and is used for grazing cattle and sheep.

The survey method used was the same as that described for the Volcanics Project. The elevations were based on the Engineering and Water Supply Department's bench marks and varied between 56 and 71 feet above Mean Low Water Level at Port Adelaide. The starting elevation was taken from the Engineering and Water Supply Department Bench Mark No. 214 , the level of which was given as 58.51 feet above the datum at Port Adelaide.

Permanent markers were placed at V.P.s 700, 688, 676 and 670. The elevations were found to be 76, 61, and 60 feet at the first three markers. V.P. 670 was not levelled.

The traverse was laid along the Old Boundary Road and two series of vibrator points were laid, firstly a series of 880 feet spreads commencing with V.P. 700 and V.P. numbers descending to the west, and secondly, a series of 1320 feet spreads commencing at V.P. 800 in the east and V.P. numbers descending to the west.

Gambier Limestone III. The traverse was situated in a region with similar topography to the previous traverse. The Gambier Limestone was more effectively covered by grass than in the previous case and no exposed rock was encountered.

Permanent markers were placed at V.P.s 900 and 893 on this traverse. The elevations of these two markers are 232 and 224 feet respectively above sea level. The starting elevation was taken from the previous conventional shot point A49 (Alliance Oil Development) where the elevation was given as 242 feet above sea level.

For both Gambier Limestone traverses the vibrator point locations were plotted on the maps (Enclosures Nos. 26 and 40) with reference to the topographical features shown on the South Australian Mines Department 1 inch to 1 mile Geological map.

Computing

For the Gambier Limestone II traverse the elevation datum used was Mean Sea Level and for Gambier Limestone III it was 50 feet above Mean Sea Level..

No weathering corrections were applied, datum corrections were computed in accordance with the formula :-

$$\frac{Ev + Eg}{Ve}$$

Where Ev and Eg were the elevations above datum at the vibrator and geophone positions and Ve was the elevation velocity. This velocity was 7000 feet per second.

The velocity function derived from T - Delta T analyses of records in the Beachport area was at first used to correct the normal move out for the Gambier Limestone II traverse. The average velocity given by this function was :-

$$V_a = 6300 + .3Z \text{ ft/sec}$$

Where Z = depth in feet.

The Beachport function was found to be slightly over correcting the curvature on the reflections. Consequently a function derived from the Geltwood Beach No. 1. well of Beach Petroleum N. L. was adopted; the value of this function is $V_a \approx 6934 + .25Z$ and it was used for the ensuing portion of the Gambier Limestone II traverse. For the Gambier Limestone III traverse the Beachport function was found to be more satisfactory.

Recording

Introduction On the outcropping Gambier Limestone, the main limitation to the record quality was found to be due to a high amplitude, low velocity interference wave.

The field technique developed on the Gambier Limestone II traverse was designed to minimise the effect of this coherent noise and also to obtain the deepest reflection data possible; this was achieved largely by the adoption of a long offset.

The field technique developed was as follows :-

Geophone pattern	-	400 geophones in a diamond pattern of length 400 feet and width 400 feet
Vibrator pattern	-	3 vibrators in line over a length of 200 feet.
No, of sweeps	-	20 per trace
Trace interval	-	88 feet
Spread offset	-	2684 – 3476 feet
Sweep frequency	-	14 – 57 cycles per second

Noise Test. The noise spread was recorded using an in-line technique as follows:-

Geophone pattern	-	10 geophones in a group zero feet in line by 10 feet wide.
Vibrator pattern	-	Zero-vibrated from one location
No. of sweeps	-	Varied from one to ten
Trace interval	-	20 feet
Offset distance	-	400 feet to nearest geophone 4380 feet to outside geophone
Sweep frequency	-	10 - 113 cycles per second

The method employed for the recording, in order to derive the ratio of the various noise events, was the same as that described for the Volcanics in line noise spread. This method was used for the distance ranging from 400 feet to 4380 feet. Subsequently this noise spread was extended to 5980 feet and a transposed method was used for the extension. The transposed technique was :-

Geophone pattern	-	50 geophones in a group 5 feet in line by 20 feet wide
Vibrator pattern	-	Zero - vibrated at each location
Number of sweeps	-	3 per trace
Trace interval	-	20 feet
Offset distance	-	4400 feet to nearest geophone 5980 feet to outside geophone
Sweep frequency	-	10 - 113 cycles per second

The Variable Area Section showing both sections combined is included as Enclosure No. 34 to this report. The noise falls into three distinct bands whose velocities are 2400 - 2800 feet per second, 3300 feet per second and 7200 feet per second. The plots of time against distance, response against wave number, response against frequency and wave number against frequency are shown on Enclosures Nos. 34-37 respectively.

During succeeding experiments it was found that the high amplitude, low velocity noise (2400-2800 feet per second) was detrimental to the record quality and that despite the relatively short wave length of this interference (75-71 feet) it appeared to be extremely difficult to cancel by the spatial filtering effect of geophone and vibrator patterns. Two more noise spreads were vibrated with a view to establishing more information on the low velocity energy and in particular any variation in the interference due to direction. The second noise spread was vibrated using the same in line technique as that shown above but the spread was reversed so that the geophones lay to the east of the vibrator. In the third case, the spread was laid at right angles to the traverse with the geophones to the north of the vibrator. The result of these two additional noise tests showed similar velocities, relative amplitudes and wave lengths to those derived from the original test and it was concluded that the noise did not have any directional characteristics.

Initial Experimentation. Five 880 feet spreads were vibrated starting at the eastern end of the line. The transposed technique employed for these initial recordings was :-

Geophone pattern	-	350 geophones in a rectangle 264 feet long by 240 feet wide.
Vibrator pattern	-	3 vibrators in line spaced 88 feet apart over a pattern length of 264 feet.
Number of sweeps	-	10 and 20 per trace
Trace interval	-	88 feet
Offset distance	-	880 feet to inner trace, 1760 feet to outer
Sweep frequency	-	14 - 57 cycles per second

This technique was chosen as a simple method to obtain sufficient continuous sub-surface coverage to enable reflections to be recognised. The pattern lengths of 264 feet were employed so that all the noise events evident on the noise spread would be attenuated. The longest interference wave length evident on the noise spread was 240 feet which was produced by the 30 cycle per second component of the highest velocity interference (7200 feet per second).

The initial recordings are shown in Variable Area Section form as enclosure No. 29. Two poor reflections are evident at 0.8 and 1.0 seconds, any shallower information is obscured by the low velocity (2400 feet per second) noise which despite the apparent adequacy of the pattern lengths employed appears on these records between the times of 0.4 and 0.8 seconds. This noise event is better demonstrated on

698 West

699 East

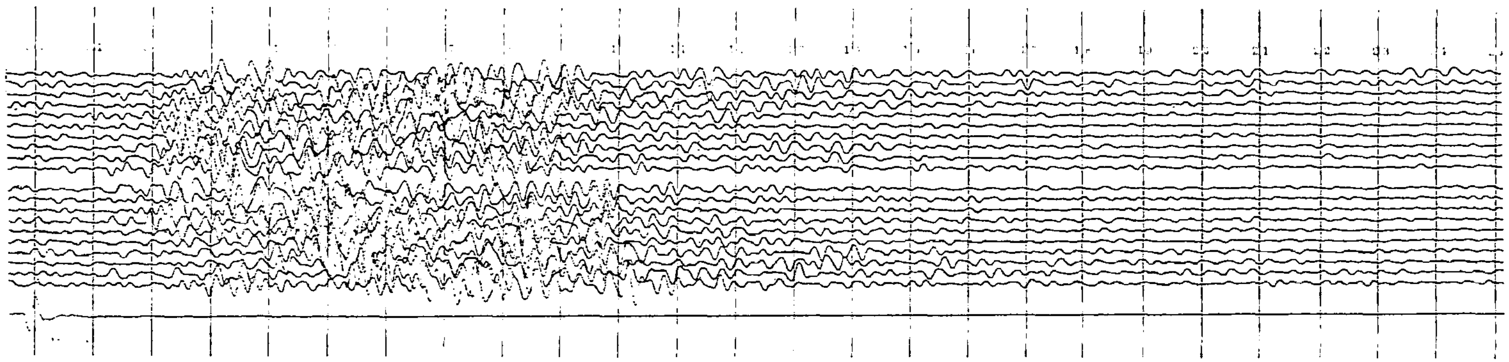


Fig. A. Uncorrected A.V.C. OFF. Field Tape 2156.

697 W.

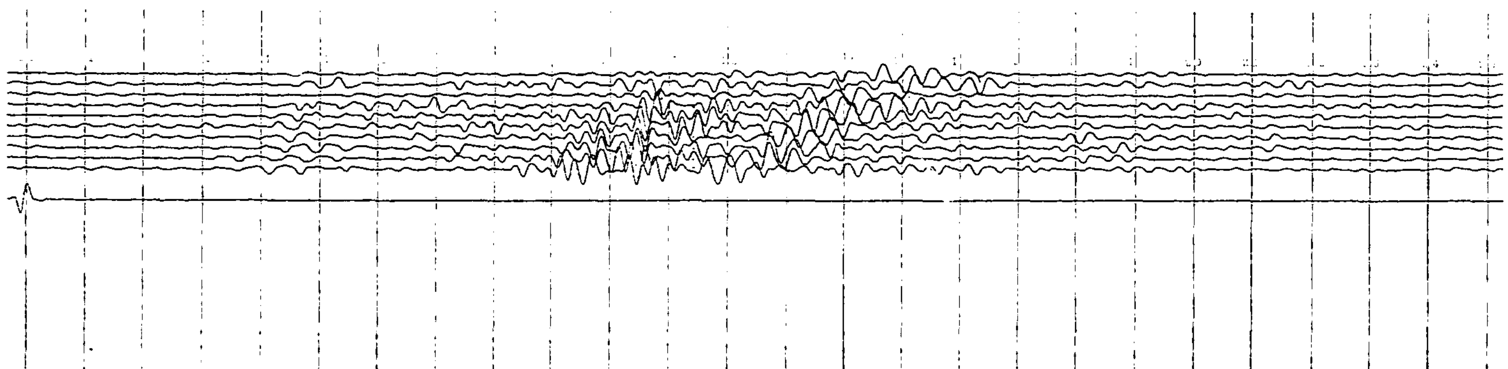


Fig. B. Uncorrected A.V.C. OFF. Field Tape 2161

PLATE (GAMBIER LIMESTONE) 1.

the uncorrected A.V.C. off record shown as Fig. A. on Plate (Gambier Limestone) 1. This record shows the interference to be the highest amplitude event on the record and would obviously prevent the appearance of reflections within the range 0.4 to 0.8 seconds.

Parameter Comparisons. The next experiment was made to firstly establish whether a better signal to noise ratio could be obtained by varying the amount of offset between the geophones and the vibrators and secondly to reveal a 'window' in the noise from which an optimum offset could be decided.

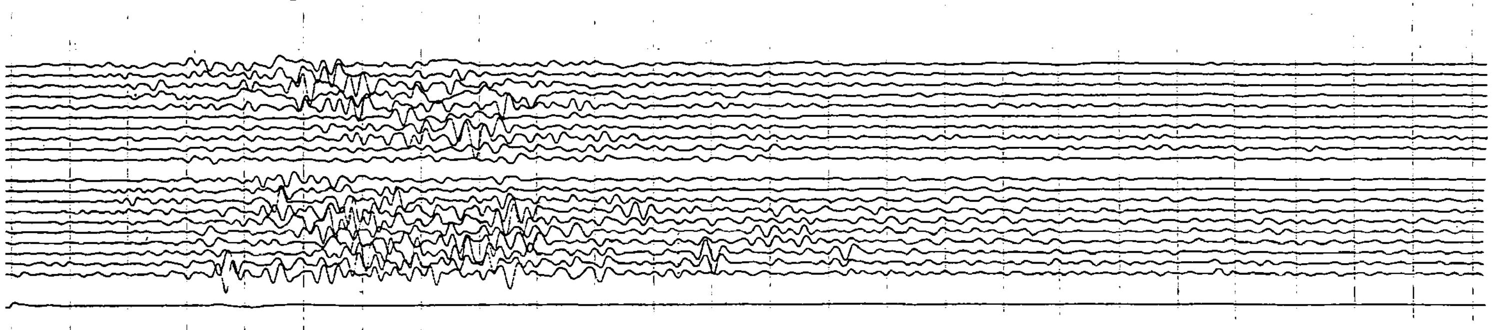
The method employed was to lay two geophone patterns at vibrator points 699 and 695 and vibrate the four intervening spreads to produce consecutive zero, one, two and three spread offsets in both directions. The details of the technique were the same as those used for the initial experiments except that the offset distance was changed. The eight profiles produced in this manner are displayed, in Variable Area Section form, as Enclosure No. 30. Most reflected energy appears within the uncorrected time range of 0.6 to 1.1 seconds at an offset distance of between 2640 and 3520 feet and is clearly evident on profile 697 west. The persistence of the low velocity noise out to this offset distance can be seen on the section and is also demonstrated on Plate (Gambier Limestone 1.) Fig. B. which shows the A.V.C. off record of profile 697 west from which the relative amplitudes of the reflection at 1.0 seconds and the low velocity noise can be assessed.

Succeeding work on this traverse was designed with two objectives in view, firstly to attempt to overcome the problem of the low velocity coherent noise, and secondly to obtain reliable information from strata within or below the Upper Cretaceous beds corresponding to times greater than 1.0 seconds. These formations had been previously found to exist to a depth of below 10,000 feet in the Mount Salt Well.

To overcome the coherent noise problem the first approach was to employ geophone and vibrator patterns whose spatial filtering attenuates the noise and the second approach was to apply electrical filtering on playback to the residual noise passed by the spatial filtering in the source and detector patterns. The difference in frequency between the noise and the reflected energy is evident on Plate (Gambier Limestone 1.) Fig. B. The application of a 40 - 60 cycle per second filter on playback provided an improvement in a reflection at a time of approximately 0.5 seconds, but a deterioration in the deeper events. This method therefore would provide a solution for the shallow part of the section.

In order to establish that no radical changes occurred in sub-surface conditions further to the west, part of the traverse (V.P. 681 to V.P. 678) was vibrated. The transposed technique used was the same as the initial recordings except that the sweep frequency was changed from 14 - 57 to 20 - 57, cycles per second. Similar record quality was obtained to that observed at the eastern end of the line.

699 East 264 feet Geophone Pattern

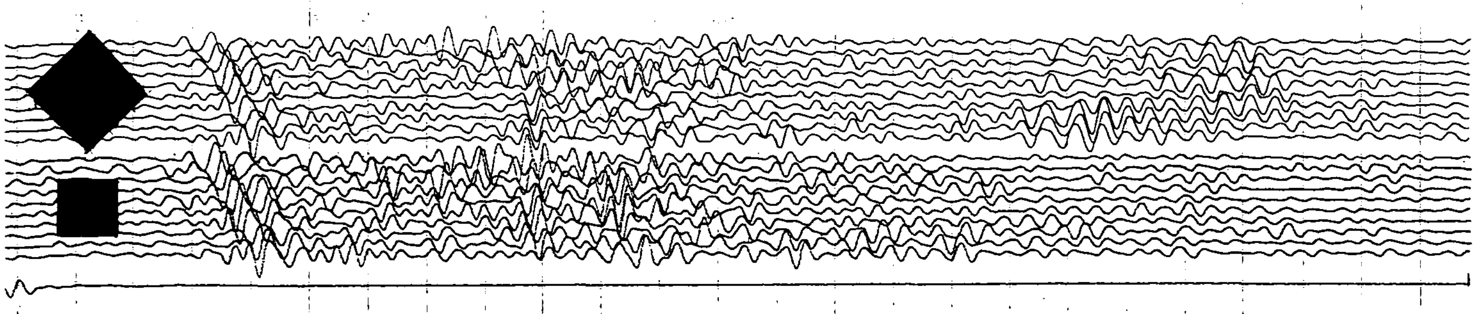


699 East 600 feet Geophone Pattern

One Spread Offset Fig. A. A.V.C. OFF. Uncorrected. 400 feet vibrator pattern. Tape 2168

699 West

699 West



Two Spread Offset Fig. B. A.V.C. OFF. Uncorrected Tape 1916

PLATE (GAMBIER LIMESTONE) 2.

In this location a comparison was made between a 20 - 57 and a 28 - 57 cycles per second sweep. Some improvement was evident in the shallow information when the higher frequency sweep was used. This is in agreement with the findings previously noted using an electrical high pass filter on playback.

Various rectangular vibrator and geophone patterns were employed in further attempts to overcome the low velocity noise. Lengths ranging from 100 to 1000 feet were compared but no apparent reduction in the noise was evident. Plate (Gambier Limestone 2.) Fig. A. shows the persistence of the noise at 880 to 1760 feet offset using a geophone pattern 264 feet long (upper profile) and 600 feet long (lower Profile).

Due to the improved theoretical filter response of a diamond pattern this pattern shape was also employed, primarily as a method of attenuating the low velocity noise. It was found however that the improvement obtained in this respect was only marginal. Fig. B. of Plate (Gambier Limestone 2.) compares the results of a square geophone pattern (200 feet by 200 feet) with a right angled diamond pattern of diagonal length 400 feet. The theoretical response curves, show that to obtain zero response at the same wave number values, it is necessary to use a diamond pattern whose diagonal length is twice that of the equivalent rectangular pattern. Fig. B. shows a slight reduction in the low velocity noise which appears within the time range 0.8 to 1.3 seconds on the upper profile recorded with a diamond pattern. The difference in quality however between the two records of profile 699 west is not great enough to provide a basis for the use of the diamond pattern.

Referring again to Fig. B. of Plate (Gambier Limestone 2.) the energy within the time range 1.8 to 2.2 seconds is considerably higher on the upper profile than the lower. On this consideration and due to the objective of obtaining information from the deeper section, the diamond was ultimately adopted as the optimum geophone pattern shape.

The optimum technique used 20 sweeps per trace largely in view of the extremely high ambient noise that existed during the production recording but it is considered that in quieter conditions 10 sweeps per trace could effectively be employed.

Field Techniques. The technique eventually adopted after the experimentation was designed principally to enhance the deep data; this was achieved largely by the adoption of a long offset spread which extended over a distance of 2684 to 3476 feet. As a consequence, reflections at times less than 0.5 to 1.0 seconds were attenuated by normal move out cancellation across the geophone and vibrator pattern lengths. This attenuation was considered acceptable in view of the lack of interest in the shallow geological section.

The details of this technique are :-

Geophone pattern	-	400 geophones in a diamond pattern of length 400 feet and width 400 feet.
Vibrator pattern	-	200 feet length with three vibrators in line.
No. of sweeps	-	20 per trace
Trace interval	-	88 feet
Spread offset	-	2684 - 3476 feet
Sweep frequency	-	14 - 57 cycles per second.

As the effective length of a diamond pattern is half the actual diagonal length, this technique differs from that employed on the initial experimentation only in the increased spread offset.

The section is shown in Variable Area Section form as Enclosure No. 27 and the quality is generally fair except between V.P. 695 to V.P. 699 and V.P. 678 to 681 where the continuity is poor.

Coverage was obtained over part of the line from V.P. 697 to 694 using both a two and three spread offset method. The details of the technique were the same as that given above except for the offset distance. Where common coverage was obtained both offset records were combined to give a two fold common depth point coverage. The Variable Area Sections showing the comparisons of these methods are included as Enclosures 31, 28 and 32 for two spread, three spread and two fold methods respectively. This indicates that the three spread offset is superior at depth and consequently the traverse was completed using this technique.

The results of the part of the line retraversed with a Common Depth Point method are shown on Enclosure No. 33

The field method employed was as follows :-

Geophone pattern	-	40 geophones in line over 200 feet.
Vibrator pattern	-	200 feet length with 3 vibrators in line at 67 feet spacing between units.
No. of sweeps	-	10 per trace

894 North

897 South

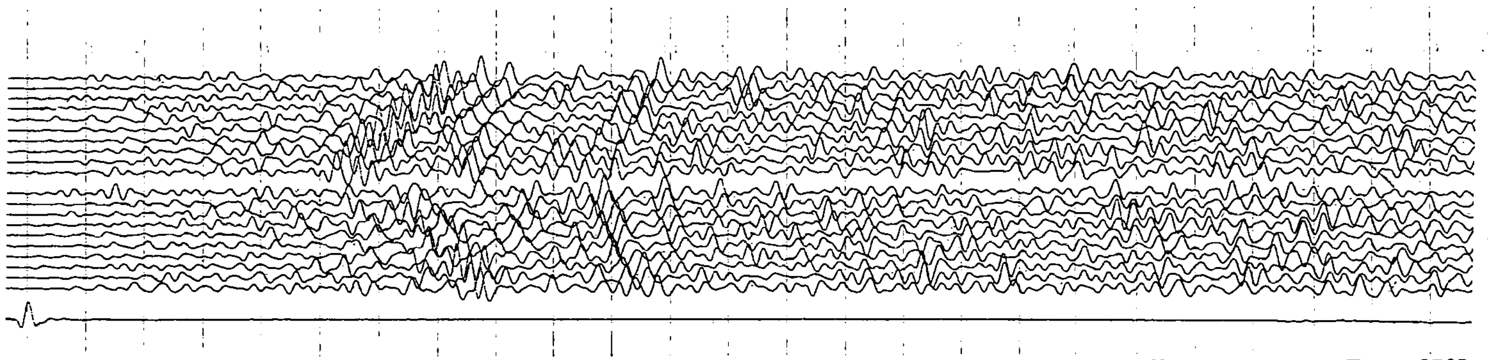


Fig. A. 2 Spread Offset Tape 2762

897 South

898 North

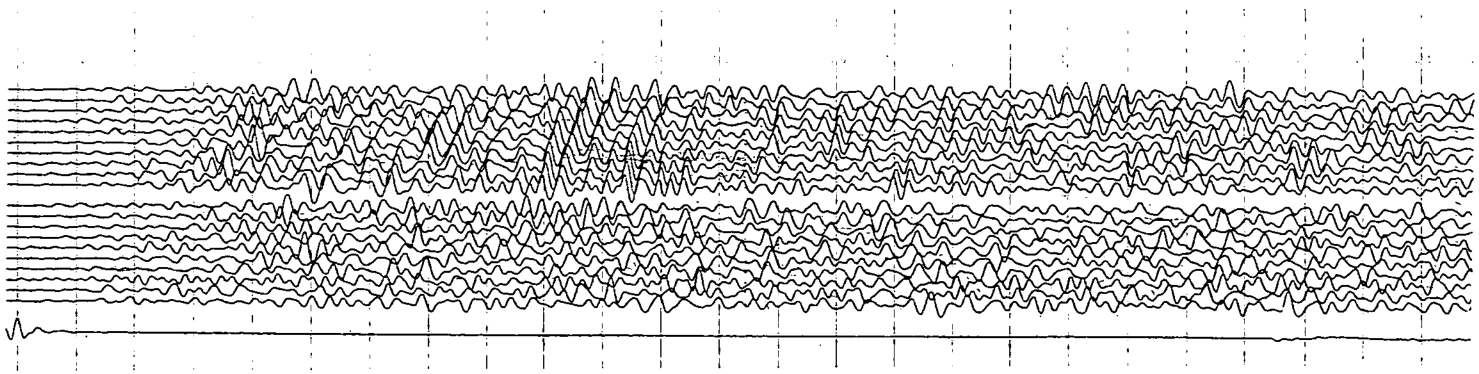


Fig. B. 1 Spread Offset Tape 2768

PLATE (GAMBIER LIMESTONE) 3.

Trace interval	-	132 feet
Offset distance	-	1386 to 3894 feet
Sweep frequency	-	14 - 57 cycles per second

By comparison with the transposed section, the common depth point method shows a reduced signal to noise ratio, probably due in the case of the shallow reflections, to a low velocity noise recorded with the near samples, and, in the case of the deeper reflections, to the reduction in the total number of ray paths composited. The continuity of the horizons down to a time of 1.0 seconds is sharper however than that obtained with the transposed method, probably due to cancellation of the high amplitude noise in the early part of the section as a result of the stacking.

The details, in chronological order, of the techniques used on the Gambier Limestone II part of the traverse are given on the schematic diagram on Enclosure No. 39.

Gambier Limestone III. Initially the field technique employed was the same as that used with the transposed method on the Gambier Limestone II traverse, except that the trace interval was increased from 88 to 132 feet and the spread offset from 2684 - 3476 to 2706 - 3894 feet. These parameters were changed in order to increase the production rate to obtain as much coverage as possible. The record quality obtained on the previous traverse, indicated that some reduction in quality, due to the increased trace interval could be tolerated. The Variable Area Section of the results presented on Enclosure No. 42 shows fair to good quality reflections and continuity within the time zone 0.6 to 1.1 seconds.

A portion of this traverse was repeated using a reduced offset of 1386 to 2574 feet and 10 sweeps per trace. The results are shown on Enclosure No. 41 and indicate an improvement in the quality and continuity of the shallowest reflection at 0.58 seconds.

Records showing the two techniques employed on this traverse are shown on Plate (Gambier Limestone) 3 and profile 897 south can be directly compared. The poor quality profile 898 north is due to a high ambient noise level caused by cattle which could not be restrained from entering the geophone pattern.

Results

Gambier Limestone II. The Variable Area Section of this traverse, Enclosure No. 27 shows penetration to times of 2.0 to 2.5 seconds which correspond to depths of 9,000 to 13,000 feet.

The quality and continuity on this section are generally fair to good. Over the central part of the section, an angular unconformity is clearly shown at a reflection time of 0.85 seconds which corresponds to a depth of approximately 3,250 feet. This unconformity may therefore be related with the Tertiary-Cretaceous boundary which occurs at this depth in the Mount Salt No. 1. bore approximately three miles to the north-west.

Above the unconformity the horizons exhibit about one and a half degrees of east dip along the line of the traverse, whereas below, the unconformity and down to depths of 13,000 feet the dip is approximately 4 degrees.

Mount Salt No. 1. bore was completed at a depth of 10,044 feet in the Upper Cretaceous Belfast Mudstone, and to date none of the bores within the south-eastern part of the Gambier Sunklands have penetrated the Lower Cretaceous. The deepest horizon which shows reliable continuity on the Gambier Limestone 2 section is at a depth of about 13,000 feet and is conformable with the overlying horizons located beneath the unconformity.

Gambier Limestone III. The results of this traverse are presented as Variable Area Section, Enclosure No. 42. Fair reflection quality and continuity are shown on several horizons within the zone 0.6 to 1.1 seconds. These horizons are conformable and show no appreciable dip; they probably lie within and near the base of the Tertiary. Below 1.1 seconds, the continuity is poor and no strong reflections can be seen on the section; the indications however are of south dip.

OTWAY BASIN

Part III Sand Dunes Project

Objectives

The objective of this project was to assess the Vibroseis method on typical areas of sand cover within the Gambier Sunklands; two types of sand areas are encountered, one comprises a gently undulating sheet of sand covering the surface, the other consists of low ranges of recent coastal dunes and consolidated fossil dunes.

Previous seismic work in the Sunklands has generally avoided these areas due to the poor quality of the results obtained and the difficulties experienced in drilling shot holes on the sand cover. However much of the previous work was of a reconnaisance nature only and little experimentation was attempted during these surveys.

The Vibroseis programme comprised three traverses with the following objectives. The first traverse, Sand Dunes I, was intended to survey a short line, without previous experimentation, in an area just off the sand sheet cover where previous conventional results were fair.

The Sand Dunes II traverse was designed for experimentation in an area of thick sand cover in order to develop the optimum Vibroseis field technique for these conditions and then to apply this technique along a short traverse and compare the results with those obtained on the Sand Dunes I traverse. After this the Sand Dunes III traverse was designed to apply the optimum field techniques developed on the Sand Dunes II sand sheet traverse along a short traverse across a typical fossil dune.

Programme

The locations of the three traverses comprising the Sand Dunes Project are shown on the Locality Map (Enclosure No. 25.).

Sand Dunes I. This traverse was located on the main road from Mount Gambier to Penola, approximately one mile to the south of Tarpeena and extended along the boundary between the Hundreds of Young and Mingbool. The recording occupied one day and employed a transposed method.

Sand Dunes 11. The traverse was sited on the same road as the Sand Dunes 1 traverse, approximately three miles further to the north and in the Hundred of Nangwarry. The line was located entirely on an area of sand surface cover. A total of five days was worked at this location, two days on experimentation and three days on production recording with a transposed method.

Sand Dunes 111. The traverse extended across the ridge of sand dunes which crosses the Robe to Penola road, approximately five miles north of Furner in the Hundred of Kennion. One day of production recording on this traverse was followed by a half day of production using a revised technique.

Topography and Survey.

Sand Dunes 1 and 11. Both these traverses were located on the main road between Mount Gambier and Penola and extended into the Hundreds of Young, Mingbool and Nangwarry. The location of the vibrator points are shown on the one inch to one mile Location Map, Enclosure No. 43.

South of Tarpeena on the Sand Dunes 1 traverse, the topography is flat and consists of open grazing country with clay soil surface conditions. However north of Tarpeena on the Sand Dunes 11 traverse, the topography is gently undulating and covered with a surface layer of sand; this sand sheet area forms one of the Radiata fir tree plantations.

Elevations varied between 237 and 242 feet above sea level on the Sand Dunes 1 traverse and between 233 and 250 feet on the Sand Dunes 11 traverse. Permanent survey markers were established at V.P.s 1000 and 993 on Sand Dunes 1 traverse and at 1100 and 1116 on Sand Dunes 11 traverse. The elevations above sea level of these four markers are 239, 240, 239 and 238 feet respectively and are tied to the South Australian Mines Department Line 4 at S.P. 3.

Sand Dunes 111. This traverse lies in gently undulating and partly wooded terrain. The relief is due to ridges of fossil sand dunes running approximately NW-SE. The Sand Dunes 111 traverse was laid along the road which passed across a fossil dune. The traverse consisted of 1320 feet spreads. Permanent markers were placed at V.P.s 1198 and 1204. The elevation at V.P. 1204 is 100 feet above sea level and is tied to the South Australian Mines Department Seismic Line S.B.

Computing

The elevation datum used for the Sand Dunes I, II, and III traverses was Mean Sea Level.

The datum corrections were computed in accordance with the formula :-

$$\frac{Ev + Eg}{Ve}$$

Where Ev and Eg were the elevations above datum at the vibrator and geophone locations.

No weathering corrections were applied. Normal move out corrections were applied using the following velocity function which was derived from previous survey results in the Beachport Area:-

$$\text{Average Velocity (Va)} = 6300 + 0.3Z$$

Where Z is the depth in feet.

Recording

Sand Dunes I. This traverse was recorded in an area off the sand sheet cover where previous conventional records (line 4) shot by a South Australian Mines Department seismic party had shown fair quality down to reflection times of above 0.9 seconds.

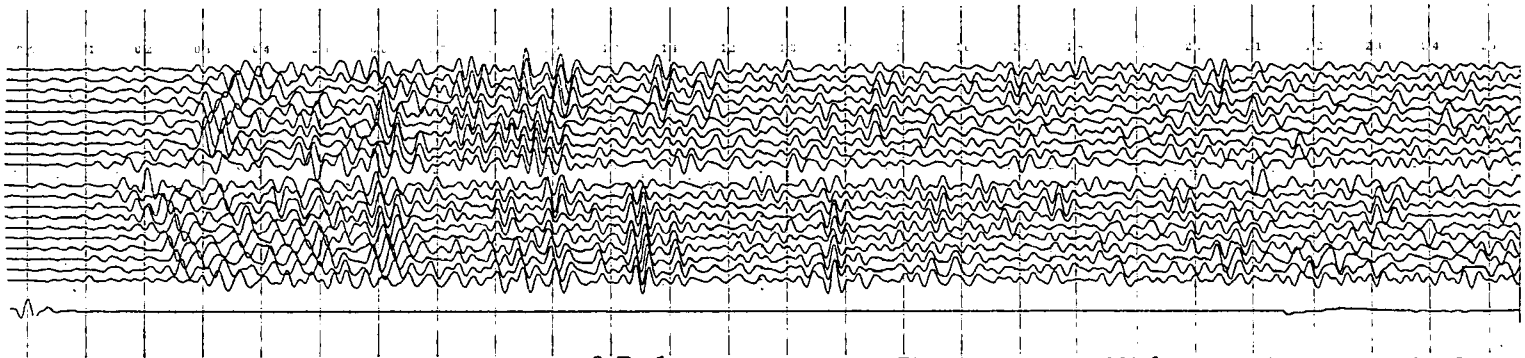
The recording of the traverse occupied one day. A transposed field technique was used which employed average values for the various parameters in order to obtain a rapid appraisal of the Vibroseis method in an area of fair conventional results.

The technique was as follows:-

Geophone pattern	-	350 geophones in a rectangle 400 feet long by 2000 feet wide.
Vibrator pattern	-	Length 400 feet with three vibrators in line.
No. of sweeps	-	10 per trace

995 South

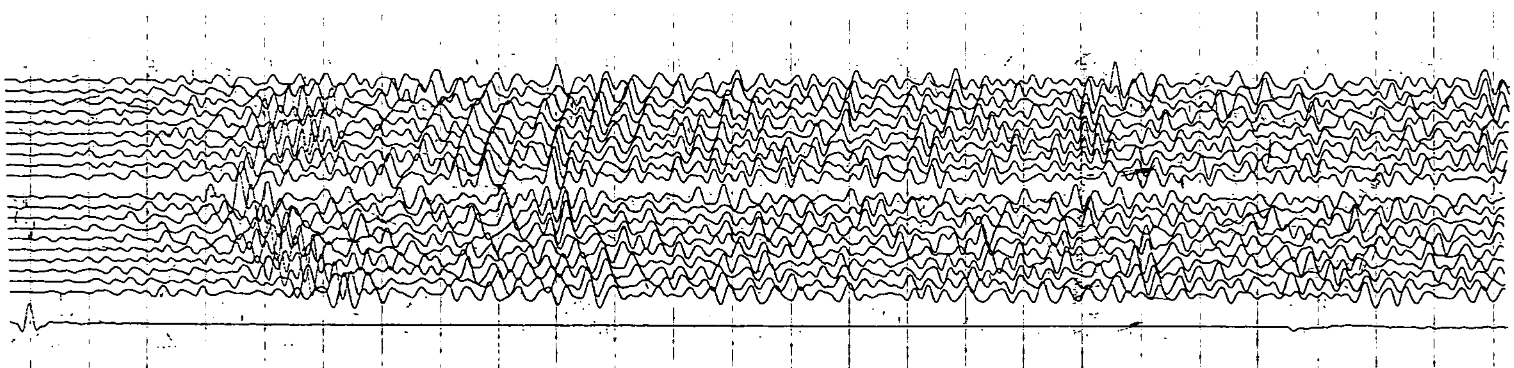
996 North



S.D. 1 Fig. A. 880 feet spread. Tape No. 2775

1103 South

1104 North



S.D. 2 Fig. B. 1320 feet spread. Tape No. 5179

PLATE (SAND DUNES) 1.

Trace Interval	-	88 feet
Offset distance	-	880 - 1760 feet
Sweep frequency	-	14 - 57 cycles per second.

The reflection quality was fair to good down to times of 1.1 seconds with weaker alignments evident to times of 1.5 seconds. The Variable Area Section of the traverse is included as Enclosure No. 44 to this report.

Plate (Sand Dunes 1.) Fig. A. of profiles 996N and 995S illustrates the quality of the data obtained on this traverse. This record shows several well defined reflections in the time range 0.6-1.1 seconds with weaker reflections at 1.4 and 1.55 seconds. It also illustrates well the cancellation effect of the geophone and vibrator patterns on the "First Breaks".

Sand Dunes II. This traverse was located entirely over an area of surface sand cover. A total of five days were worked, two days were occupied on limited experimentation and three days on the production recording.

Noise Test The experimentation commenced with the recording of an interference spread over a total distance of 4000 feet; the technique used for this noise test was :-

Geophone pattern	-	10 geophones in a group 0 feet in line by 10 feet transverse.
Vibrator pattern	-	Zero - vibrated from one location.
No. of sweeps	-	Varied from one to ten.
Trace interval	-	20 feet
Offset distance	-	550 feet to nearest geophone and 4130 feet to the farthest
Sweep frequency	-	10 - 113 cycles per second.

Two principal velocities were observed at 2500 and 6600 feet per second. Alignments were also recorded at times of between 0.6 and 0.9 seconds with an apparent velocity of 18,500 feet per second and these constituted reflected energy. This reflected energy could be distinguished on the interference section at offset distances of from 1000 to 2000 feet where the divergence of the two principal interference velocities formed a 'window' in the interference pattern between 0.6 and 0.9 seconds.

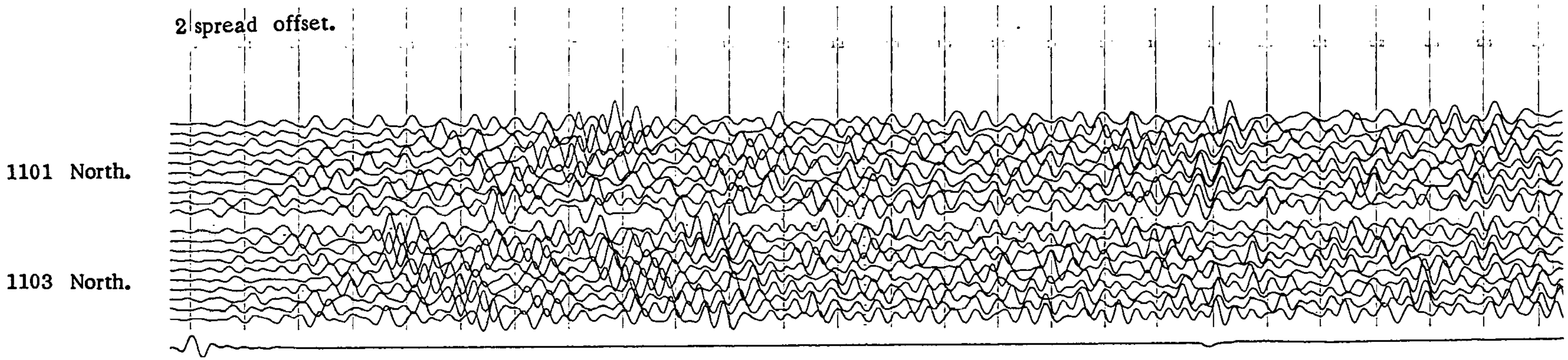


Fig. A. 10–40 C.P.S. sweep. Tape 5176

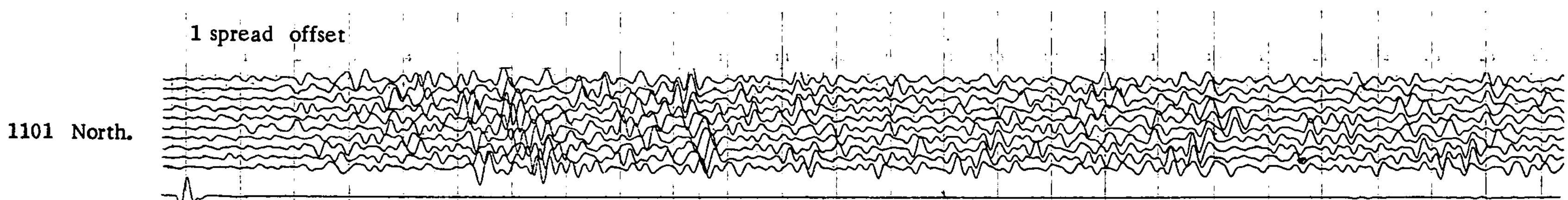


Fig. B. 14–57 C.P.S. sweep. Tape 5122

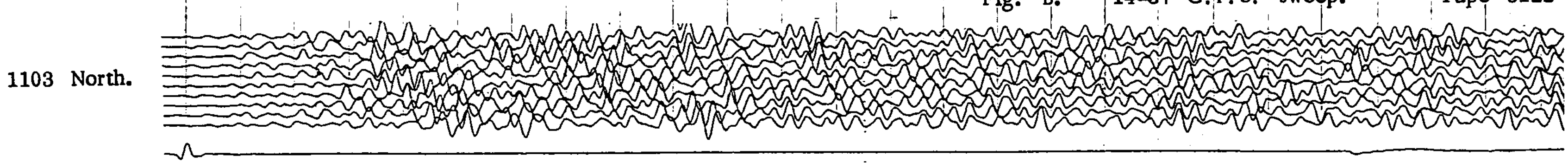


Fig. C. 14–57 C.P.S. sweep. Tape 5125

PLATE (SAND DUNES) 2. (All records uncorrected).

The interference spread was repeated over offset distance of 2150 to 2930 feet using sweep frequencies of 14 - 40 and 28 - 57 cycles per second. This frequency comparison showed the amplitude of the interference to be greatest with the lower frequency sweep and indicated that the low velocity interference was largely composed of low frequency components.

The interference spread showed a mean reflection pulse frequency of about 35 cycles per second which is the mean frequency of the 14 - 57 cycles per second sweep. To obtain maximum attenuation of the higher velocity interference of 6600 feet per second at the mean sweep frequency of 35 cycles per second a pattern length of 190 feet would be required; however to obtain maximum attenuation of the lowest frequency component of a 14 - 57 sweep would require a length of 470 feet.

With pattern lengths of 470 feet and long offsets, attenuation of the shallow reflection would occur since the low average velocity in the area would produce excessive normal move out time differences across the length of the pattern. Therefore in this area, the pattern length chosen had to be a compromise. In order to enhance the weaker deep reflections it was desirable to utilise large pattern lengths and long offsets to attenuate the surface interference. Conversely large pattern lengths and long offsets resulted in attenuation of the shallow reflections.

Parameter Comparisons. One spread was repeated using a lower sweep frequency of 10 - 40 cycles per second in order firstly to produce sub-surface profile 1103 N at the same 1320 - 2640 feet spread offset as a sweep frequency comparison and secondly profile 1101N with an increased 2640 - 3960 feet spread offset. This record is shown as Fig. A. on Plate (Sand Dunes 2.)

On profile 1101 N with the increased offset, the deep alignment at approximately 1.8 seconds was slightly enhanced but the shallower events at 0.5 - 1.0 seconds were very severely attenuated. This can be seen by comparing with Fig. B. Plate (Sand Dunes 2.) On profile 1103 N, the lower 10 - 40 cycles per second sweep frequency showed no improvement over the previous record at 14 - 57 cycles per second, Fig. C. Plate (Sand Dunes 2.) and bears out the conclusion from the noise test that the low velocity interference is largely composed of low frequency components.

The remaining parameter varied was the number of sweeps per trace. On this traverse penetration was thought to be limited by attenuation within the surface sand layer and by the high ambient traffic noise levels. Three production spreads were therefore recorded with 40 sweeps per trace to give profiles 1111 S - 1114 N and although a slight improvement was observed in the quality of the deeper events on certain

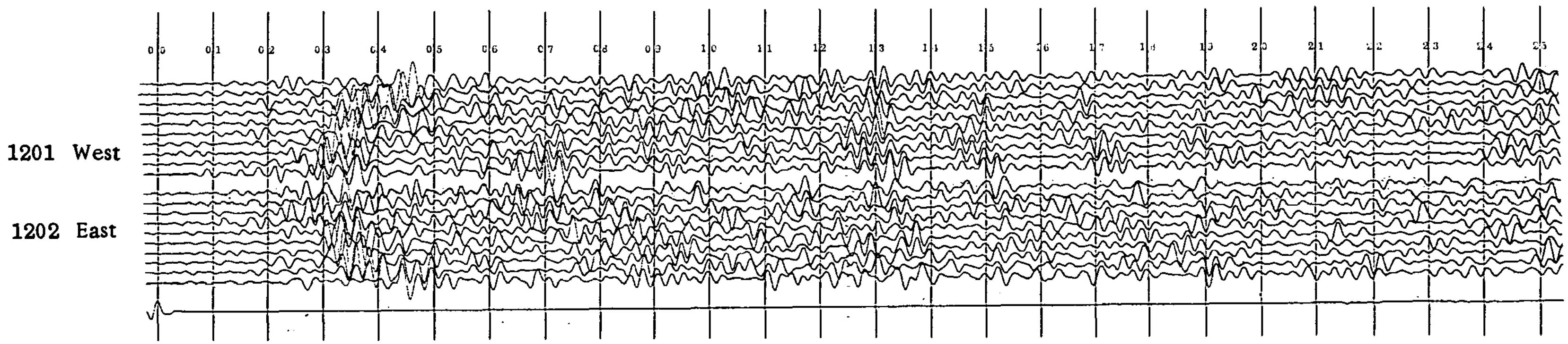


Fig. A. Typical record for Sand Dunes III traverse. Tape 5196

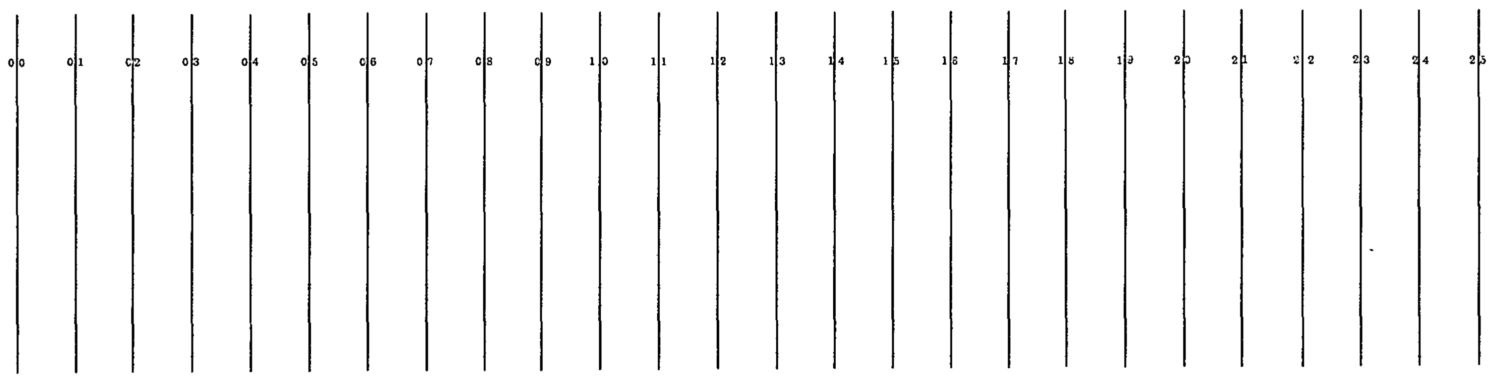


PLATE (SAND DUNES) 3.

profiles no real improvement in the continuity can be seen on the section (Enclosure No. 45); is was therefore considered that 20 sweeps per trace was an optimum for production recording on this line.

Field Techniques For the Sand Dunes II traverse therefore a compromise pattern length of 400 feet was selected with a spread offset of 1320 – 2640 feet. The technique used was as follows:-

Geophone pattern	-	400 geophones in a rectangle 400 feet long by 180 feet wide.
Vibrator pattern	-	Length 400 feet with three vibrators in line
No. of sweeps	-	20 or 40 per trace
Trace interval	-	132 feet
Spread offset	-	1320 – 2640 feet
Sweep frequency	-	14 – 57 cycles per second

Plate (Sand Dunes 1) Fig. B. showing profiles 1104 N and 1103 S illustrates the quality of the data obtained with this technique.

A comparison of the Variable Area Sections for the Sand Dunes I and Sand Dunes II (Enclosures Nos. 44 and 45) traverses illustrates the effect of increasing the offset and trace interval. On Sand Dunes I these parameters were 880 feet and 88 feet respectively whereas on Sand Dunes II they were increased to 1320 feet and 132 feet.

A comparison of the sections shows better signal to noise ratio and resolution of the shallow reflections on the Sand Dunes I section.

However the results at depth are better on the Sand Dunes II section. This is due partly to the increased offset, but probably also to the increased number of sweeps employed on this traverse.

Sand Dunes III. The object of this traverse was to test the effectiveness of the field technique developed on the Sand Dunes II traverse across a typical fossil sand dune.

Plate Sand Dunes 3 of profiles 1201 W and 1202 E illustrates the record quality which was lower than that obtained on the Sand Dunes II traverse. On profile 1201 W, a fair quality alignment can be seen at 1.3 seconds but otherwise the alignments are weak and interrupted. No experimentation was programmed for this traverse, however one spread was repeated to produce profiles 1199 E and 1202 E at two and three spread offsets respectively. For this test the vibrator and geophone pattern lengths were reduced to 200 feet in an endeavour not to attenuate any shallow reflections. The record however was of poor quality and showed no obvious alignments.

The coherent noise on this traverse was of higher amplitude than on the Sand Dunes II line and this is thought to account largely for the deterioration in the record quality. It appears from this, assuming the sub-surface to be similar, that the consolidated state of the sand contained in the fossil dunes permits energy to be dispersed within the near surface and thus contributes to both the coherent noise and energy absorption problem.

Results

Sand Dunes I and II. The Variable Area Section of Sand Dunes I shows good reflection quality and continuity on several horizons within the time range 0.5 - 1.1 seconds. Within this range, the horizons are conformable and exhibit south dip. At times greater than 1.1 seconds, the reflection continuity is not good but some poor alignments are shown down to a time of 1.5 seconds.

The section of Sand Dunes II shows a strong band of reflections which, at V.P. 1113, lie within the time range of 0.55 to 0.75 seconds. These reflections are conformable and demonstrate about 2 degrees of south dip. By extrapolation southwards, it would appear that they correspond to reflections recorded at times between 0.85 - 1.05 seconds at V.P. 999 on the Sand Dunes I section.

A weaker reflection at 1.0 second at V.P. 1113 may be followed across the section with reasonable certainty and there are indications of deeper reflections which also show south dip down to times of 2.0 seconds. Since no well data is available in the immediate vicinity of the Sand Dunes I and Sand Dunes II traverses, it is not possible to correlate the seismic horizons with the geological formations with any degree of certainty.

However an interpolation between the logs of the Penola No. 1 and Mount Salt No. 1. bore indicates that in the Tarpeena area, the top of the Cretaceous should be at a depth of about 2000 feet which corresponds to a reflection time of about 0.6 seconds. Thus it may be postulated that, on Sand Dunes I and Sand Dunes II traverses, the strong hand of reflections which dip to the south, from times of 0.55 – 0.75 seconds at V.P. 1113 to times of 0.9 – 1.1 seconds at V.P. 994 corresponds to beds at, or just beneath, the Tertiary-Cretaceous boundary. On this assumption the deepest conformable reflection recorded, at a time of 1.8 seconds at V.P. 1101 would correspond to a bed approximately 5000 feet below the top of the Cretaceous.

Sand Dunes III The recording of this traverse was conducted using the same technique as that employed on the Sand Dunes II traverse. The reflection quality is poor, although events with poor definition and continuity are apparent, at the western end of the section (Enclosure No. 49) at times of 0.6, 1.25 and 1.4 seconds.

OTWAY BASIN

PART IV INTER-DUNAL POOR REFLECTION AREA

Objectives

Previous conventional surveys have observed a gradual deterioration in the reflection quality southwards towards the centre of the Gambier Sunklands. The most significant deterioration occurs in the area north east of Beachport No. 1. well where very poor results were obtained on traverses sited between the sand dune ridges, although quite simple field techniques had yielded good results further to the north.

The objective of the Vibroseis survey was to assess the method on a short inter-dunal traverse and to investigate the reason for the deterioration in the quality of the conventional results.

Programme

The location of the Inter-dunal Poor Reflection Area (I. P. R.) traverse is shown on the Locality Map, Enclosure No. 25.

The traverse was situated on the main road from Millicent to Adelaide about seven miles to the north of its intersection with the Robe-Penola road. Three days only were worked on this project, one day on experimentation and two days on transposed production recording.

Topography and Survey

In the areas between the dune ridges the terrain was flat. The traverse was sited along a sealed road which extended across open grass pasture land. Recent rains had caused extensive flooding in the area and large areas of surface water lay on both sides of the road and in adjoining paddocks.

The elevation varied between 34 and 41 feet above sea level. The traverse was tied into S. P. 60 on the South Australian Mines Department Seismic Line CK for which an elevation value of 35 feet was given. Permanent survey markers were established at V. P. s 1300, 1292, and 1284; at these points the elevations were 36, 35, and 37 feet respectively.

The spreads laid were 1320 feet between vibrator points and their locations were plotted on the map shown as Enclosure No. 50 to this report.

1295 South

1296 North

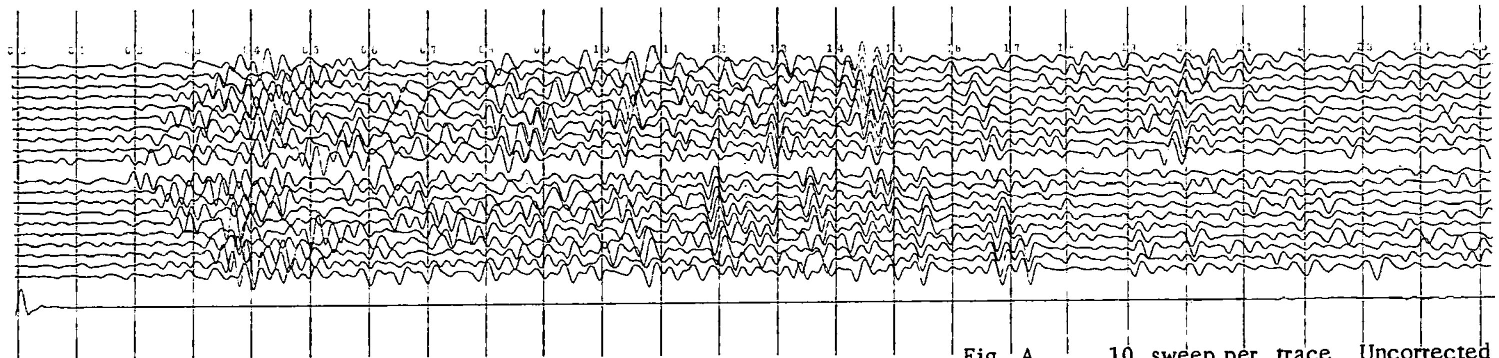


Fig. A. 10 sweep per trace Uncorrected

1295 South

1296 North

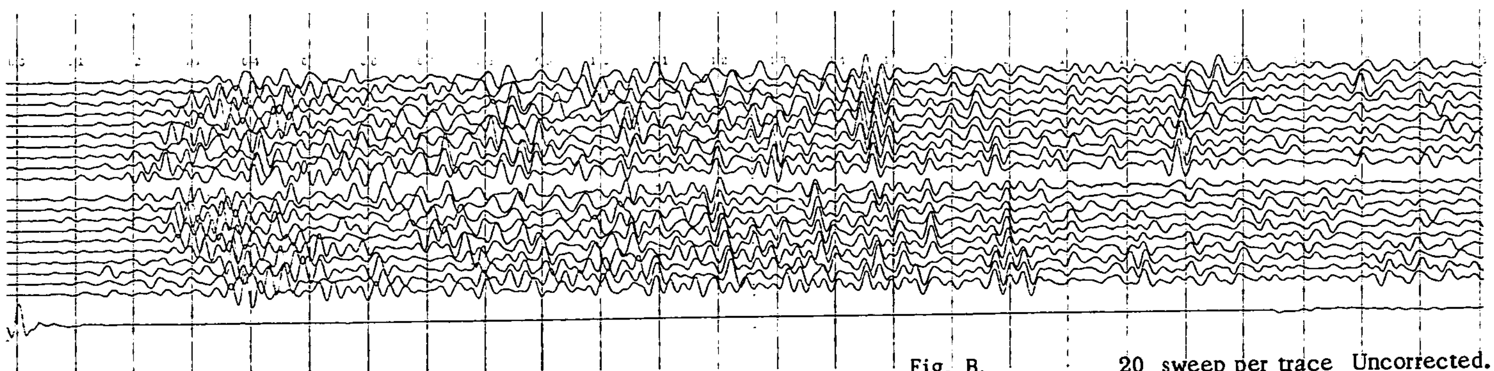


Fig. B. 20 sweep per trace Uncorrected.

PLATE (I. P. R.) I

Computing

The elevation datum was Mean Sea Level; a correction to datum was determined using an elevation velocity of 7000 feet per second. No weathering corrections were applied.

Normal move-out corrections were applied using the Beachport Function given by :-

$$Va = 6300 + 0.3Z \text{ feet per second}$$

Where Z is the depth below datum in feet and Va is the average velocity.

Recording

Since the previous seismic work in this area had not suggested any reasons for the deterioration in record quality, the I. P. R. Vibroseis traverse was commenced using a technique based on that found to be optimum for the Sand Dunes II traverse. This technique was selected due to the similarity of the surface conditions.

The method employed was as follows :-

Geophone pattern	-	400 geophones in a rectangle, 400 feet long by 180 feet wide.
Vibrator pattern	-	Length 400 feet with three vibrators in line
No. of sweeps	-	10 per trace
Trace interval	-	132 feet
Offset distance	-	1320 – 2640 feet
Sweep frequency	—	14 – 57 cycles per second.

The initial results with this technique were encouraging however the record quality later proved to be variable. This variation in quality was probably associated with the extensive flooding in the area which frequently necessitated planting geophone arrays under up to two feet of water.

Plate (I. P. R.) 1. Fig. A. profiles 1295 S and 1296 N illustrates the best quality obtained and shows several good quality reflections down to times of 2.0 seconds. This record is compared with the same profiles recorded with the number of sweeps per trace increased from 10 to 20 on Fig. B. and demonstrates that adequate penetration is achieved with 10 sweeps per trace at this point.

On profiles 1298 S and 1299 N, a further comparison was made between the two sweep frequencies of 14 - 40 and 14 - 57 cycles per second; the records showed similar alignments but the introduction of the higher frequencies in the 14 - 57 sweep improved the definition of the reflection at 1.5 seconds.

A further experiment produced profile 1297 N from a two spread offset and profile 1299 S from a zero offset and each of these profiles were compared to those produced from the normal one spread offset. The two spread offset record produced no improvement on the deep event at 1.5 seconds however, on the zero offset record, fair alignments could be seen at both shallow and at depth on the outer traces. The inner traces were obliterated due to the overlap of the vibrators into the geophone nest.

In addition, a short transposed interference spread was recorded (Encl. No. 52) which revealed evidence of reflected energy at times of 0.4 and 0.5 seconds over offset distances of 600 to 2000 feet.

As a result of these experiments, it was decided to complete the line to the south of V.P. 1294 with a reduced half spread offset of 660 - 1980 feet, the field technique in all other respects remaining the same. With this technique a slight improvement in the quality and continuity of the shallow data can be observed on the Variable Area Section, Enclosure No. 51, but the deeper data is poorer and it is considered that the use of this half spread offset technique is generally not as effective as the one spread offset method in this area.

Results

The Variable Area Section, Enclosure No. 51, shows fair to poor continuity on several weak horizons between 0.8 and 1.7 seconds. These horizons are conformable and indicate a gentle northerly dip.

Over the southern part of the section a poor alignment, showing south dip, can be discerned at a time of approximately 2.0 seconds. Indications of possible faulting exist at this depth below V.P. 1294 - 1295.

OTWAY BASIN

CONCLUSIONS

The overall results of the Vibroseis Experimental Survey in the Otway Basin are considered to be satisfactory in that the seismic problems were overcome in all but one of the four projects.

In the regions of basalt cover within the Portland Sunklands, the Vibroseis methods evolved during the experimental programme succeeded in penetrating the near surface basalt and yielded structural information from the geological section beneath.

Prior to the commencement of this survey, it had been suggested that the conventional results using the common depth point method were poor mainly due to rapid variations in the weathered layer and lateral changes in the average velocity. The results obtained on this survey have shown that it is possible to successfully stack the widely dispersed surface samples obtained when employing the common depth point method. It is therefore considered that these two factors do not constitute a major obstacle to the use of this method in the areas of basalt cover.

Although extreme velocity contrasts exist at the interfaces of the basalt layers, the results of the survey show that sufficient seismic energy penetrates these near surface layers to provide adequate energy return at the geophones from the deeper reflectors.

To the west in the Gambier Sunklands, most of the experimentation was conducted in the areas of exposed Gambier Limestone and loose surface sand cover. In these areas good results were obtained. However both on and off the surface sand cover, the results at depth are weak which indicates that the seismic problem in this area is one of high earth absorption and unfavourable stratification within the deeper formations, rather than a lack of penetration through the surface layers.

In the two remaining areas, the traverse lay across a fossil dune and a region of swampy ground between sand dune ridges. In these areas a minimum of experimentation was performed and the seismic problems were not completely delineated. The results however suggest that the problems may be similar in these two regions and it is suggested that the seismic problem may therefore not be directly related to the geological surface conditions and thus cannot be anticipated from consideration of the surface geology alone. It is recommended that further experimental work be conducted in the regions of the Sand Dunes III and Inter-Dunal traverses to fully investigate their seismic problems.

An important factor to be considered in determining the optimum field technique for areas within the Otway Basin is the extremely low average velocity values which prevail throughout the basin.

In determining the dimensions of the various seismic parameters such as spread length, offset distance and pattern lengths, careful consideration must be given to the cancellation effect on the shallower reflections due to excessive normal move out and dip; this cancellation is emphasised by the low average velocity distribution and can become the limiting factor. In order to obtain the maximum information from the deeper part of the section, large pattern lengths and long offsets are normally desirable and it is therefore necessary to accept some cancellation and distortion of the shallowest reflections. Thus the technique to be adopted may of necessity represent a compromise determined by the particular zone of interest within the sedimentary section of the area under consideration.

During both the Volcanics and Gambier Limestone Projects, a spread length of 880 feet was employed with the transposed method and this was adhered to in order to obtain the highest quality results. However it is considered that for production purposes the spread length could be increased to 1320 feet whilst maintaining adequate quality for reliable interpretation. Similarly on certain of the Gambier Limestone and Sand Dunes traverses, the technique employed 20 sweeps per trace in order to achieve the maximum information at depth. Again it is considered that for a production survey, reliable information from the stronger shallow reflectors could be obtained by reducing the number of sweeps per trace to 10.

The production rate to be expected using the Vibroseis transposed methods adopted during this survey is dependent mainly upon the spread length and the number of sweeps per trace. With techniques which employed an 880 feet spread length and 10 sweeps per trace, a production of 1 2/3 miles was achieved; with a 1320 feet spread length and 10 sweeps per trace the production was increased to 2 miles per day. With technique which used 20 sweeps per trace these production figures were reduced by about one half.

The ten fold common depth point method used during this survey, employed a trace interval of 132 feet and a production of 1 mile per day was achieved.

Throughout the Gambier Sunklands survey, the weather conditions prevailing were those of high winds and heavy rainfall. The winter conditions in South-East South Australia are normally considered unsuitable for conventional seismic operations and it is considered that the overall record quality would have been considerably improved if the survey had been carried out during the summer season.

SYDNEY BASIN

Synopsis

The Experimental Vibroseis Survey in the Sydney Basin was conducted by Seismograph Service Limited, Party 243, on behalf of the Bureau of Mineral Resources, Geology and Geophysics, during the period 24th August to 3rd October, 1964.

The survey comprised two projects which were designated the Hawkesbury Sandstone Project and the Built-Up Area Project.

The first project was located in two areas, one in the vicinity of the Kulnura No. 1. bore and the other about 30 miles further to the west in the Grassy Hill area on the Windsor-Singleton road. A total of 27 and a half working days were occupied on this project.

The seismic problem presented when recording on the Hawkesbury Sandstone had been considered due to energy losses within this formation. Previous conventional seismic results had generally been poor and had not produced reliable data at depth.

The Vibroseis results have demonstrated that good quality reflections can be readily obtained from the strong reflectors associated with the Upper Coal Measures which lie at the top of the Upper Permian Section. In addition reliable data was obtained by the use of long offsets and large pattern lengths down to depths of approximately 12,000 feet.

The second project consisted of a traverse through the densely populated and heavily built-up residential area of the City of Maitland where conventional shot hole methods using explosive charges are impractical. The objective was to assess the results of the method in a typical built-up area and also to tie together two previous conventional seismic traverses which could not otherwise have been joined. A large part of the Sydney Basin is heavily built-up and populated and the results of this project were therefore considered pertinent to the exploration problems of this basin.

The Vibroseis results show data to depths of about 8,000 feet and over the major part of the traverse, a strong and continuous reflector was recorded, which probably corresponds to the Greta Coal Measures. The Built-Up Area traverse occupied six working days.

SYDNEY BASIN

GEOLOGY AND PREVIOUS GEOPHYSICS

Geology

The Sydney Basin consists of Permian and Triassic sediments deposited unconformably upon Devonian and Silurian rocks which are often found to be metamorphosed in exposures around the edges of the basin. The limits of the basin are bounded by the Permian rocks which are covered in turn by a blanket of continental Triassic sediments. Minor Tertiary intrusions occur sporadically throughout the basin.

The Permian series shows evidence of two marine transgressions, each followed by continental coal measure periods. The uppermost continental sequence contains Permian coal measures overlain by Triassic strata. The thickness of the Permian system varies from 16,000 feet in the north to 5,000 feet in the south but is unknown in the central area. The Permian normally passes, without any apparent depositional break, into the lower beds of the Triassic Narrabeen Group; however, in at least one place, an angular unconformity is present at this boundary.

The Triassic rocks are the most widely exposed and have an average thickness of 4,000 feet. They are divided into three main groups of which the basal Narrabeen, a quartz sandstone with shales and conglomerates, is the thickest. Above this lies the Hawkesbury Sandstone which is a massive coarse sandstone with some conglomerates and shaly lenses. The uppermost formation is the Wianamatta Group, which consists largely of freshwater shales and occurs mainly as small exposures on the Hawkesbury Sandstone plateaux.

It is developed more extensively to the south-east.

The structure of the basin is dominated by the Lochinvar Anticline in the north whose axis trends approximately north-south and possibly runs into the more gently folded Kulnura Anticline further south; several other folds have their axis parallel to this major trend. In general, in the centre part of the basin, Permian structure is reflected by less intense structure in the overlying Triassic sediments.

The most prominent feature in the western part of the basin is the Lapstone Monocline which produces a structural relief of 1100 feet down to the east.

The Permian dark shales and siltstones are the main possible source beds, particularly those in the Upper Marine. However, few good reservoirs have been penetrated so far and even the thin sands in the base of the Triassic and the top of the Permian lack good permeability. A number of wells have been drilled in the northern part of the basin to test the Marine Permian and traces of fluorescence were detected in the loder No. 1. bore within the Lower Marine Dalwood Group.

Previous Geophysics

Magnetic

The Australian Oil and Gas Corporation Ltd., has made an extensive aeromagnetic coverage of the Sydney Basin. The magnetic method has proved to be useful for reconnaisance in determining the structure of the Sydney Basin. However the presence of Volcanics within the Marine sequence is known to have produced a false impression of the magnetic basement depth and as a consequence it is difficult to clearly define other than major structures in the sedimentary section using this method.

Gravity

Little interpretational work has been carried out on the gravity results obtained in the Sydney Basin, however from the B.M.R.'s initial work on a Bouguer Anomaly Map, integrating all gravity work to date, two salient features emerge. Firstly a gravity low associated with the southern extension of the Kulnura Anticline and secondly a high in the Lapstone Monocline area. The low in the structurally high area suggests a granitic basement here and the high over the Lapstone Monocline is probably associated with Volcanics.

From the above it appears that a reverse gravity correlation exists in at least part of the Central Sydney Basin.

Seismic.

The Bureau of Mineral Resources conducted an experimental seismic survey in the Sydney Basin in 1957. The applicability of the seismic method in areas with various outcropping formation was tested but no complex methods were attempted. Shooting was carried out on the Upper Triassic Wianamatta Shale and Hawkesbury Sandstone in the central part of the basin and on the Permian Newcastle Coal Measures in the Hunter River Valley.

Fair results were obtained on the Wianamatta shale but only poor results were obtained in test areas on the Hawkesbury Sandstone.

Since 1957, a considerable amount of seismic work has been carried out throughout the basin. This work has generally been confined to areas with little or no Hawkesbury Sandstone on the surface. In regions away from exposed Hawkesbury Sandstone generally fair quality results have been obtained and where poor results occur in these areas, the reason has been attributed to disturbed sub-surface conditions.

Seismic work on the Australian Oil and Gas Corporation Ltd., Line AJ, situated on exposed Hawkesbury Sandstone produced fair to poor results from the shallow part of the section, but no continuous reflections were recorded at depths greater than 4,000 to 5,000 feet below the surface. On that part of Line L, situated approximately 3 miles to the north of Line AJ on more rugged Hawkesbury Sandstone in the vicinity of Kulnura No. 1. bore, very poor results were obtained and no reflections are evident on the section.

The rugged terrain and dense bush had imposed severe limitations on the conventional experimentation on Line L. The only effective variables tried were the charge depths and sizes. These were varied between 160 and 100 feet and 15 to 25 lbs. respectively in single holes. Eight geophones per trace were used, spaced at 15 feet along the line of traverse.

Several seismic surveys within the Sydney Basin have been hampered by their proximity to built-up populated areas. In the Maitland Area, complete seismic coverage was restricted by the high density of residential areas and the presence of a number of near surface coal mines.

The only previous seismic work carried out in this area was a reflection survey in April, 1962 for Planet Exploration Pty. Ltd. One strong and continuous reflector was mapped in the area and this was shown to correspond to the Greta Coal Measures by a subsequent velocity survey and sonic log in the

East Maitland No. 1. bore.

The standard field technique utilised a 1,320 feet straddle spread, 12 geophones per trace and an average charge size of 25 lbs. in a single deep hole. Some improvement in record quality was obtained when 3 holes in a linear pattern were used. Recordings were made on magnetic tape with a wide filter band and were then played back through a 17 - 52 cycles per second filter with 25% mixing of traces.

Details of the reports from which this section on Geology and Previous Geophysics was compiled are given in the Acknowledgements Section of this report.

SYDNEY BASIN

Part I HAWKESBURY SANDSTONE.

Objectives

The Hawkesbury Sandstone is a hard quartzitic sandstone which is exposed over a large part of the Central Sydney Basin. Conventional seismic results on this formation have been generally poor especially at depth and previous seismic work in the Sydney Basin has largely been restricted to areas which have no Triassic Hawkesbury Sandstone on the surface. Access problems exist due to the extremely rugged topography of the Hawkesbury Sandstone areas, and shot hole drilling is difficult and expensive due to the hard and abrasive nature of the sandstone.

The objective of the Vibroseis Survey was to assess the capabilities of the method by experimentation on two traverses located on exposed Hawkesbury Sandstone in the vicinity of Kulnura No. 1. bore where previous conventional results were available for comparison purposes and then to apply the techniques developed during this experimentation along traverses located on the sandstone in a different part of the basin.

The Seismic problem imposed by this sandstone had been considered to be chiefly one of energy penetration especially to the deeper beds in the section.

Programme

The locations of the two traverses comprising the survey in the Kulnura Area are shown on the Locality Map, Enclosure No. 57. Both traverses lie on exposed Hawkesbury Sandstone.

Hawkesbury Sandstone I. The traverse was situated along the road from Wiseman's Ferry to Gosford within the Shire of Gosford. The line straddles the village of Mangrove Mountain and coincides with the Australian Oil and Gas Corporation Limited, Singleton-Camden, Seismic Survey, Line AJ, Shot Points 7 - 16.

Hawkesbury Sandstone II. This traverse was located approximately five miles to the north of the first traverse on the road from Kulnura to Wyong and is partly within the Shire of Gosford and partly within the Shire of Wyong. The traverse coincides with Australian Oil and Gas Corporation Ltd., Line L. The Kulnura No. 1. bore is sited approximately half a mile to the south-west of V.P. 1485 on the Hawkesbury Sandstone II traverse.

A total of 22 days were worked on these two traverses, 8 and a half days on production recording using a transposed method and 13 and a half days on experimental work.

Hawkesbury Sandstone III and IV. The location of the area of these two traverses is also shown on the Locality Map. Traverse III lies along the road from Windsor to Singleton, 4 miles to the north-east of Grassy Hill. Traverse IV extends to the east from the northern end of Traverse III and was sited along a forestry track which followed the crest of the Womerah Range. Both traverses lie within the Shire of Colo.

The recording on the Hawkesbury Sandstone III and IV traverses occupied 5 and a half days and no detailed experimentation was carried out.

Topography and Survey.

Areas within the Sydney Basin where the Hawkesbury Sandstone is exposed have an extremely rugged topography due to erosion which has created deep gorges with the sandstone forming vertical cliffs. In general in these areas access is difficult and the seismic traverses have to be sited along the sandstone ridges; in most cases these ridges are covered with a thick growth of timber.

The location of the four Hawkesbury Sandstone traverses are shown on the Location Maps, Enclosure Nos. 58 and 59, at a scale of 1 inch to 1 mile.

All the spreads were chained and the distance checked by tacheometry; the vibrator point locations were plotted with reference to the one mile military map sheets. Vertical control was carried out using a Watt's No. 1 microptic theodolite.

Hawkesbury Sandstone I and II. These traverses coincided with the previous conventional traverses, Lines AJ and L, and the elevations were tied to these two lines at S.P. 15 on Line AJ and S.P. 20 on Line L. The levels at these two shot points were given as 936.5 and 1132.5 feet above Mean Sea Level respectively. On these two traverses the elevations varied between 841 and 1175 feet

Permanent markers were placed at V.P.s 1400, 1415, 1482, 1492 and 1500; the elevations at these points were respectively 849, 1032, 1135, 1164 and 1121 feet above Mean Sea Level.

Hawkesbury Sandstone III and IV. On the Hawkesbury Sandstone III traverse a swampy surface layer of recent alluvium covers the sandstone from the south end of the line as far as V.P. 1605; along the Hawkesbury Sandstone IV traverse, the elevations rise and the sandstone is exposed along the entire line except for the region between V.P.s 1701 and 1703 which is located on the Upper Triassic Wianamatta Shale. These geological boundaries are shown on the V.P. Location Map, Enclosure No. 87.

The elevations for these two traverses were based on Bench Mark No. SSM 396 established on the Windsor-Putty road by the Department of Lands and Survey, N.S.W. This control point was situated at the intersection of the two traverses and its elevation was given as 1222.75 feet above sea level.

On the Hawkesbury Sandstone III and IV traverses, the elevations varied between values of 1066 and 1295 feet. Permanent markers were placed at V.P.s 1600, 1698 and 1709 at which points the elevations were 1164, 1255 and 1066 feet above Mean Sea Level respectively. An additional marker placed at V.P. 1610 was not levelled.

Computing.

Hawkesbury Sandstone I and II. These traverses coincided with Lines AJ and L. of the previous Australian Oil and Gas Corporation Ltd., Singleton-Camden Seismic Survey. To conform with the results of the previous survey, the same elevation datum of 800 feet above sea level was adopted. Similarly the same values for the weathering and elevation velocities of 3,000 and 10,000 feet per second were used in computing the datum corrections.

The computation of the datum correction assumed a constant thickness of 40 feet for the weathered layer and was given by the formula :-

$$\frac{Ev + Eg - 2dw}{Ve} + \frac{2dw}{Vw}$$

Where Ev and Eg are the elevations of the vibrator and geophone points, dw is the depth of weathering and Vw and Ve are the weathering and elevation velocities.

No irregularities due to weathering variations were observed by an examination of the curvature of the strongest reflections recorded.

Hawkesbury Sandstone III and IV. The elevation datum was 1,000 feet above sea level. No weathering corrections were applied. Elevation corrections were applied using a velocity of 10,000 feet per second.

Below datum, normal move out corrections were applied using the velocity function derived from the sonic logs from the Loder No. 1. and East Maitland No. 1. wells. The function was found to be satisfactory in removing the curvature due to normal move out on reflections for all the four Hawkesbury Sandstone traverses.

The instantaneous velocity at a depth of Z feet for this function is given by the following formula :-

$$Vi = 12,000 + 0.6Z \text{ feet per second.}$$

During the course of the experimental programme on the Hawkesbury Sandstone I traverse, profiles 1407S to 1407N were recorded from offsets of 1386-2574 feet and again from offsets of 2706-3894 feet. A velocity analysis was carried out on the records from these six adjacent profiles and the results showed good agreement with the average velocity values given by the above function.

On the rugged topography of the Hawkesbury Sandstone, the traverses followed existing roads or tracks in order to avoid the difficulties and expense of clearing trails through this heavily forested area. Parts of the Hawkesbury Sandstone II and IV traverses thus followed meandering roads and it was necessary to consider the effect of the meanders in applying the dynamic corrections.

On the Hawkesbury Sandstone II traverse, the spreads were laid out along the road and followed its meanders. The 'straight line' distance between the vibrator and geophone was measured for each trace and the approximate dynamic correction to this distance was then applied sequentially during playback.

On the Hawkesbury Sandstone IV traverse, a different method was adopted; a mean line of traverse was first established and the spreads were plotted along this line at the normal constant intervals. The actual geophone and vibrator positions were then staked out along the meandering track at points which were projections at right angles from the mean line of traverse. This method is illustrated on Enclosure No. 73.

By using this method deviations of up to 15 degrees can be tolerated without introducing appreciable differences between the actual distances between the vibrators and geophones and the distances as measured along the mean line of the traverse. Normal dynamic corrections were then applied and the need to compute individual correction for each trace was avoided provided the meandering was not excessive.

Recording

Introduction As a result of the experimentation conducted on exposed Hawkesbury Sandstone, the following field techniques were developed :-

Geophone pattern	-	360 geophones in a rectangular pattern of length 600 or 1000 feet
Vibrator pattern	-	3 vibrators in-line over a length of 600 or 1000 feet
No. of sweeps	-	20 per trace
Trace interval	-	132 feet
Offset distance	-	1320 - 2640 or 2640 - 3960 feet
Sweep frequency	-	14 - 40 cycles per second.

Maximum information from the deeper part of the section was obtained using the longer pattern lengths and offsets; however with this technique the normal move-out across the length of the patterns resulted in excessive attenuation of the shallower reflections.

The better shallow information was obtained using the shorter values of pattern length and offset distance and the 'optimum' technique for this area therefore depends upon the particular zone of interest within the sedimentary section.

Noise Test. The field work was commenced by vibrating a noise spread on the Hawkesbury Sandstone I traverse. So that relative amplitudes of the interference events could be recovered, and all records show approximately the same amplitudes, the method of 'weighting' each recording, according to its distance from the vibrator, was employed. This method is described in detail in the Volcanics Project which forms Part I of the Otway Basin section of this report.

The method employed for the field recording of the noise spread was :-

Geophone pattern	-	10 geophones in a group 0 feet in line by 10 feet transverse.
Vibrator pattern	-	Zero - vibrated from one location.
No. of sweeps	-	varied from one to ten.
Trace interval	-	20 feet.
Offset distance	-	400 feet to nearest geophone 4280 feet to outside geophone

Sweep frequency - 10 - 113 cycles per second

Part of the noise spread, offset distance from 2000 to 2780 feet, was revibrated using firstly a sweep frequency of 28 - 80 cycles per second and secondly of 10 - 40 cycles per second. The Variable Area Playback of the noise spread together with the repeated sweep comparisons is included as Enclosure No. 65. The associated time-distance, response-frequency, response-wave number and frequency-wave number plots are shown as Enclosure Nos. 66 and 67.

The principal refracted event has a velocity of 13,600 feet per second which is attributed to the Hawkesbury Sandstone. A second noise event is apparent with a velocity in the region of 6000 feet per second. A third low velocity band of interference is evident range from 1600 to 2600 feet per second. Although this event has a high relative amplitude at short offset distances it is rapidly attenuated in the ground and does not persist, with any significant amplitude, beyond 1500 feet from the source. Reflected energy appears on the section with an apparent velocity of 31,000 feet per second within the offset range of 1600 to 3200 feet and at an uncorrected reflection time of approximately 0.65 seconds.

The sweep frequency comparison indicates that the noise with a velocity of 6000 feet per second is composed almost entirely of frequencies below 28 cycles per second. This noise event is within the time range 0.7 to 1.0 seconds.

On the wide band sweep the relative amplitude is higher than on the low frequency sweep; however the event is not perceptible on the records made using the 28 - 80 cycles per second sweep. The reflected signal is apparent on both comparison sections.

Hawkesbury Sandstone I and II.

Initial Experimentation. Due to the appearance of reflected energy on the interference spread, it was considered that the coherent noise in the area of Hawkesbury Sandstone I traverse was not sufficiently high to present a major problem. An initial recording was made on this traverse without extensive experimentation to provide a first appraisal of the Vibroseis method and to compare the results with those obtained from the previous conventional work on the coincident A.O.G. Line AJ. The transposed field technique was as follows :-

Geophone pattern - 360 geophones in a rectangular pattern of length 600 feet and width 200 feet.

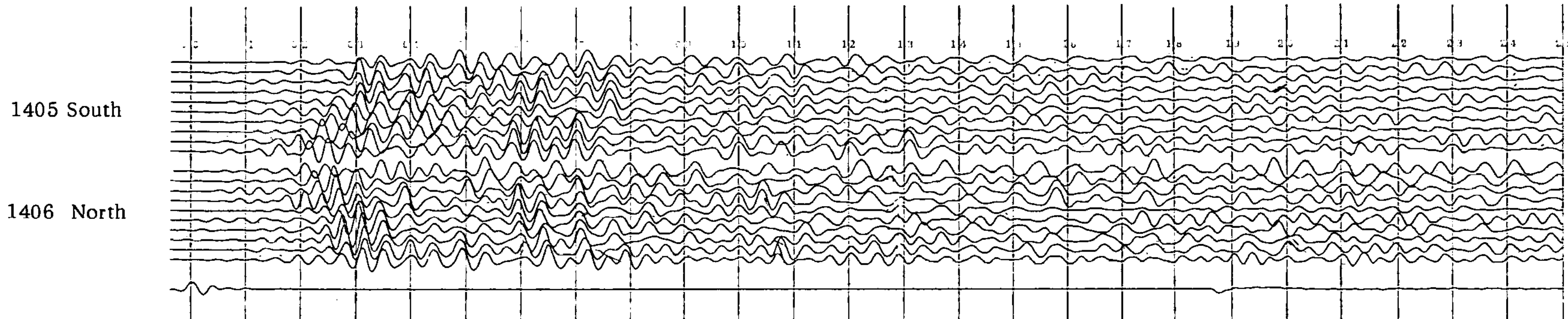


Fig. A. 10 sweeps per trace Tape 5219

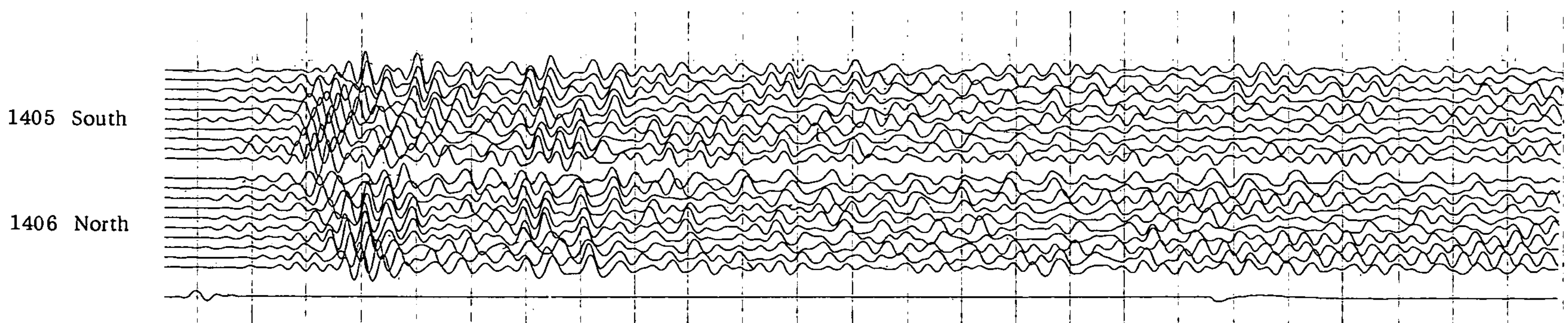


Fig. B. 40 sweeps per trace Tape 5220

PLATE (HAWKESBURY SANDSTONE) 1

Vibrator pattern	-	3 vibrators spaced at 200 feet intervals over a length of 600 feet.
No. of sweeps	-	10 per trace
Trace interval	-	132 feet
Offset distance	-	1320 - 2640 feet
Sweep frequency	-	10 - 40 cycles per second.

These parameters were chosen for the following reasons :-

(1) The geophone and vibrator pattern length of 600 feet was selected in order to attenuate the high velocity (13,600 feet per second) noise. This refracted event shows a minimum mean pulse frequency of 22 cycles per second which corresponds to a wavelength of approximately 600 feet.

(2) 10 sweeps per trace were used so as to obtain as much coverage as possible on which to base the initial assessment.

(3) The offset distance of 1320 to 2640 feet was based on the appearance of reflected signal on the noise spread within these limits.

(4) The sweep frequency of 10 - 40 with a mid-frequency of 25 cycles per second was chosen primarily because the reflected energy evident on the noise spread had a frequency of 25 cycles per second, Also on the conventional recordings from this traverse some events, particularly at depth, are evident with a fundamental frequency of less than 20 cycles per second. The presence of high voltage power lines in the region of this traverse produced considerable high line pick-up. This was eliminated by the correlation process as no output occurs at 50 cycles per second when a 10 - 40 cycle per second sweep is employed.

The results of this method are shown in Variable Area Section form on Enclosure No. 60 and compare favourably with the conventional Line AJ results. A strong band of reflected energy exists within the time range 0.5 - 0.7 seconds. Little information was recorded at greater times and due to the interest in the deeper section, succeeding experimentation was directed towards obtaining results at greater depths.

Parameter Comparisons. The first attempt to improve the deep information was to increase the number of sweeps per trace from 10 to 40 whilst maintaining the same spread geometry as the initial recordings described above,. Plate (Hawkesbury Sandstone) I shows on Fig. A. profiles 1405 S and 1406 N recorded with 10 sweeps per trace and, on Fig. B. with 40 sweeps per trace. No improvement is evident and this was considered to be due to the ratio of the amplitude of the deep and shallow reflection being too great to enable both signals to be recorded simultaneously.

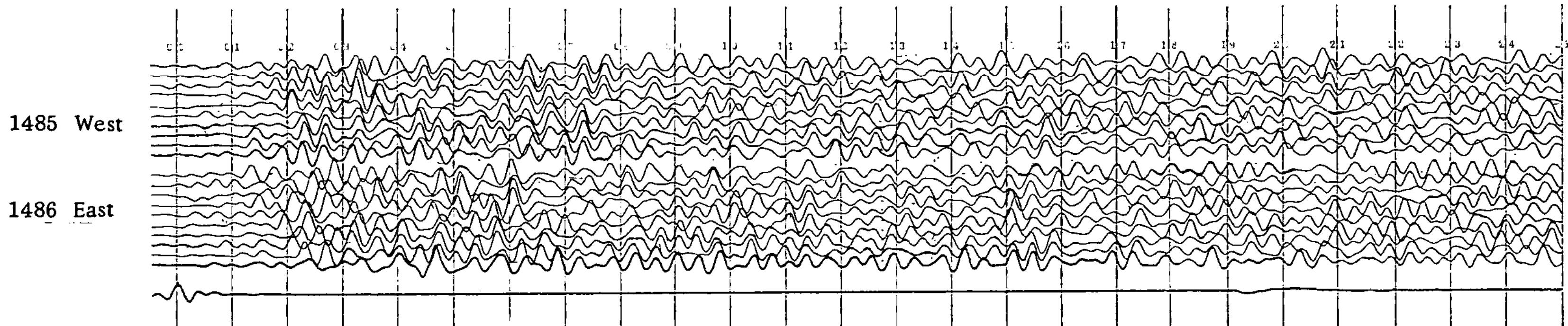
A series of experiments were then made, designed specifically to reduce the ratio between the shallow and deep information by causing the shallow reflections to be attenuated by normal move out cancellation. Part of the line between V.P.s 1407 and 1409 was selected for these experiments and was vibrated to produce four sections. The parameters varied for the four sets of recordings were the pattern lengths, and the offset distance. For these comparisons the number of sweeps per trace was increased to 20.

The first two methods employed 600 feet patterns with a two spread offset 2706 - 3894 feet, (Enclosure No. 61) and a three spread offset, 4026 - 5214 (Enclosure No. 62). The three spread offset method shows some improvement in a deep reflection at 1.8 seconds, however the shallow information between 0.5 and 0.7 seconds is almost cancelled out by excessive move-out across the pattern at this offset whereas on the two spread offset section this information is usable.

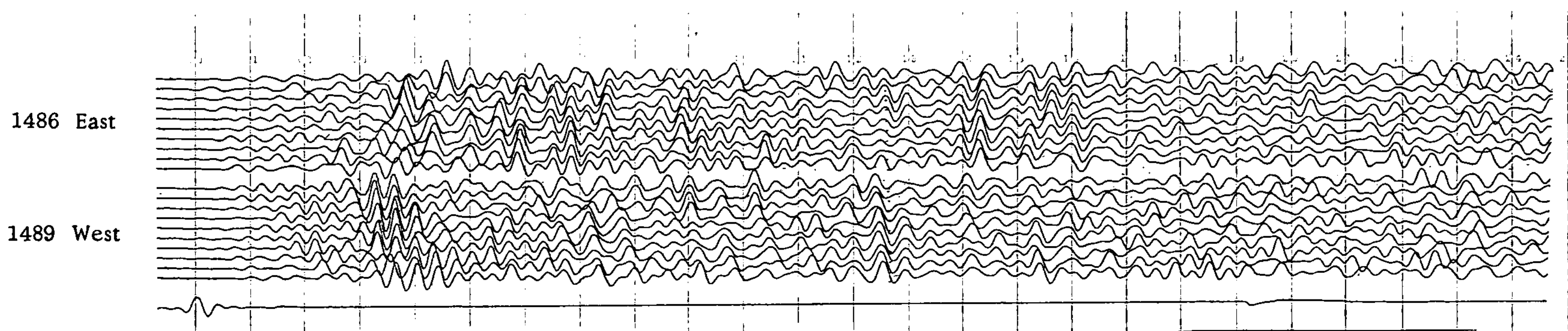
The next two methods employed the same offset distances but the geophone and vibrator pattern lengths were increased to 1000 feet. These are shown on Enclosures Nos. 63 and 64, being two and three spread offsets respectively. The deep reflection at 1.8 seconds is considerably improved using the longer offset but as before information in the region of 0.7 seconds is lost. The optimum method therefore in this area is considered to be the two spread offset in conjunction with 1000 feet patterns. This method provided usable information from 0.7 seconds to 1.8 seconds.

Part of the traverse, from V.P. 1403 to 1406 was also vibrated using 10 sweeps per trace with a three spread offset; the results however were poor and the deterioration in the reflection quality, in this case, is attributed to the reduction from the optimum, 20 sweeps per trace to 10.

Field Techniques. On the eastern part of the Hawkesbury Sandstone II traverse, the one spread offset method described above was used. The previous conventional results were extremely poor and because of the difference in the results between A.O.G.'s AJ and L Lines, it was thought that different problems existed. The first records obtained on the Hawkesbury Sandstone II traverse showed that although the quality of the shallow reflection was not as high as on Hawkesbury Sandstone I, the Vibroseis results did not differ so radically as the conventional sections indicated. At this stage the experimental work was continued on the Hawkesbury Sandstone I traverse and, after completion there, the optimum two spread offset method was used on Hawkesbury Sandstone II traverse wherever the



Typical record Fig. A. One Spread Offset Tape 4312



Typical record Fig. B. Two Spread Offset Tape 2897

PLATE (HAWKESBURY SANDSTONE) 2.

operational hazards, due to bends in the road, permitted, firstly to fill in whatever gaps existed in the one spread offset coverage and secondly to extend the line further to the west.

Two sections are included for the Hawkesbury Sandstone II traverse. Firstly Enclosure No. 69 shows the entire traverse; the eastern part, V.P. 1494 - 1499, was recorded using a one and two spread offset. The technique is listed below :-

Geophone pattern	-	360 geophones in a rectangular pattern of length 600 feet and width 200 feet.
Vibrator pattern	-	3 vibrators spaced at 200 feet intervals over a length of 600 feet.
No. of sweeps	-	10 per trace
Trace interval	-	132 feet.
Offset distance	-	1320 - 2640 and 2640 - 3960 feet.
Sweep frequency	-	10 - 40 cycles per second.

For the western part of this section the field technique used was that obtained as the optimum during the experimental work on Hawkesbury Sandstone I. Those profiles which could not be vibrated using a two spread offset method are designated one spread offset (1o.s.) at the bottom of the section.

The second section for the Hawkesbury Sandstone II traverse is shown on Enclosure No. 70. The technique was the same as that used for the one spread offset section of Hawkesbury Sandstone I, Enclosure No. 60, except that the vibrator and geophone pattern lengths were increased to 1,000 feet. The objective was to delineate more closely the structure in the shallow part of the section by revibrating the part of the traverse nearest to the Kulnura Bore (V.P. 1485) using the optimum technique for shallow information.

Plate (Hawkesbury Sandstone) 2 compares the quality between the one spread offset method on Fig. A. and the two spread offset method on Fig. B. The records are uncorrected and demonstrate the improvement particularly at depth produced by the longer offset.

<u>Hawkesbury Sandstone III.</u> No experimentation was carried out on this traverse. The technique was selected primarily for simplicity in order to obtain as much production in the first day's work as possible. A secondary consideration was that the Sydney Basin is thought to be shallower in this region than in that of the two previous traverses; the geometry of the field recording was therefore designed to accommodate

the expected thinner section and was the same as that employed on the initial experimentation on the Hawkesbury Sandstone I traverse which produced good shallow data.

The field technique was as follows :-

Geophone pattern	-	360 geophones in a rectangular pattern 600 feet long and 200 feet wide.
Vibrator pattern	-	3 vibrators in line over a pattern length of 600 feet.
No. of sweeps	-	10 per trace.
Trace interval	-	132 feet
Offset distance	-	1320 - 2640 feet
Sweep frequency	-	10 - 40 cycles per second.

The Variable Area Section of this traverse is shown on Enclosure No. 71 and an uncorrected record illustrating the reflection quality obtained is presented on Plate (Hawkesbury Sandstone) 3, Fig. A.

Hawkesbury Sandstone IV. This traverse employed the same technique as the Hawkesbury Sandstone III except that, due to a deterioration in the record quality, the number of sweeps was increased from 10 to 20 from V.P. 1704 to the east.

This line is situated on exposed Hawkesbury Sandstone except for the region between V.P.s 1701 and 1703 where a cover of Upper Triassic Wianamatta Shale obscures the sandstone. From the section it can be seen that this surface cover has little effect on the record quality. The deterioration in quality from V.P. 1704 to the east is thought to be due largely to the occurrence of coherent noise events having a high apparent velocity. These events may be due to reflected refractions from the steep sides of the spur on which the line is situated.

The Variable Area Section included for this traverse (Enclosure No. 72) has a 3/2 composite applied on playback. A typical uncorrected record from this line is shown on Fig. B. of Plate (Hawkesbury Sandstone) 3.

Results.

Hawkesbury Sandstone I and II. The results of the complete Hawkesbury Sandstone I traverse are presented as Enclosure No. 60. This Variable Area Section shows a strong band of reflections within the

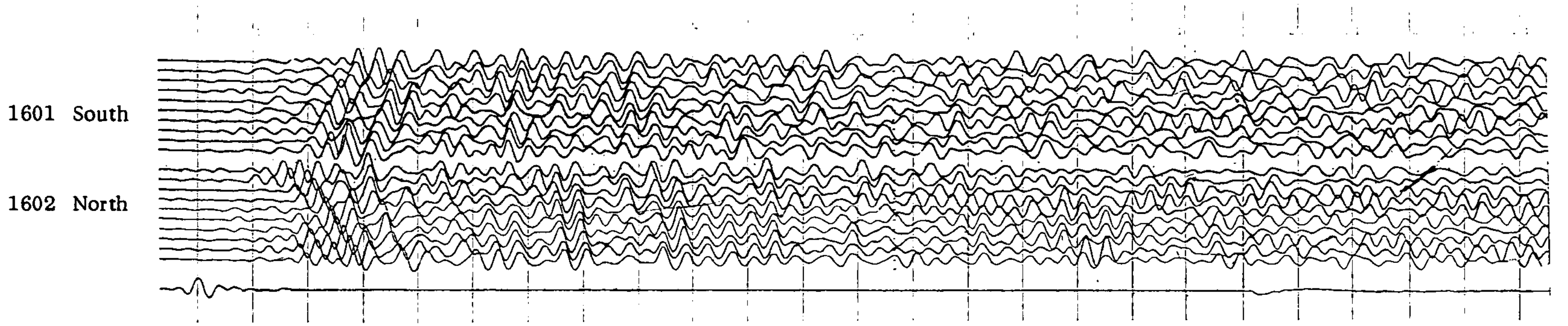


Fig. A. Typical record. H.S.3. Tape 4316

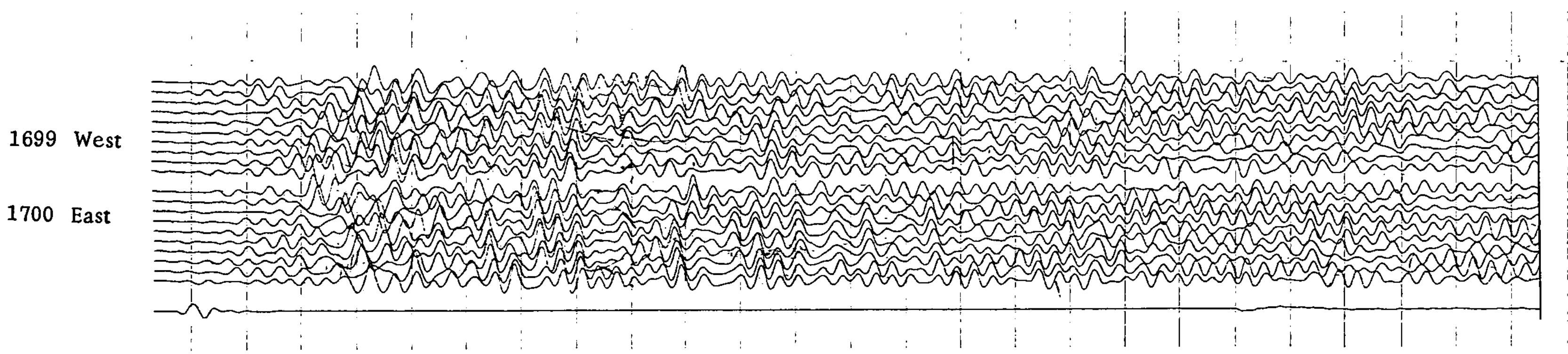


Fig. B. Typical record H.S.4. Tape 2789

PLATE (HAWKESBURY SANDSTONE) 3.

range of 0.5 - 0.7 seconds, which is essentially flat across the length of the traverse and probably corresponds to the Upper Coal Measures which lie at the top of the Upper Permian section. Enclosure No. 64 illustrates the major improvement in the quality of the deep reflections when employing long offsets; an horizon can be clearly followed across this short section at a time of 1.8 seconds which exhibits gentle south dip.

The section for the Hawkesbury Sandstone II traverse, Enclosure No. 69 shows several horizons between 0.5 and 1.5 seconds; the shallowest strong horizon at 0.5 seconds at the extreme eastern end of the Hawkesbury Sandstone II traverse can be character correlated reasonably well with the strong event at about 0.55 seconds on the Hawkesbury Sandstone I traverse. At the nearest point to the Kulnura No. 1. bore, V.P. 1485, this horizon is at a reflection time of 0.5 seconds which corresponds to a depth of 3,200 feet below the seismic datum (sea level plus 800 feet) and probably represents a bed within the Upper Coal Measures. This horizon shows an overall gentle south east dip with an anticlinal reversal centred between V.P.s 1486 and 1487. The deepest continuous horizon on this traverse occurs between 1.4 and 1.5 seconds and shows similar structural relief; this reflection time corresponds to a depth of about 11,000 feet. This traverse coincides with the conventional seismic line, Line L. The Vibroseis section shows a major improvement in record quality at all depths compared to the conventional section.

Hawkesbury Sandstone III and IV. The results of these traverses are shown on the Variable Area Sections, Enclosure Nos. 71 and 72. On both traverses good continuity is shown on four horizons at times between 0.5 and 1.0 seconds, except to the east of V.P. 1703 on traverse IV where the continuity can only be established with difficulty. All these horizons are conformable and show little structural relief. On traverse IV there is evidence of a major synclinal reversal at V.P. 1705 - 1706. Beneath these horizons the reflection quality and conformity is much weaker but there is evidence of a deeper horizon at a time of about 1.5 seconds which over the Hawkesbury Sandstone III traverse shows pronounced north dip.

SYDNEY BASIN.

Part II BUILT-UP AREA

Objectives.

Conventional seismic methods require the detonation of explosive charges in shot-holes and therefore cannot operate within built-up areas without causing damage to property and disruption of the normal town activities.

A large portion of the Sydney Basin is heavily built-up and densely populated and it has not therefore been practical to conduct seismic traverses within these areas by means of the conventional method. The Vibroseis method however can operate in built-up areas with a minimum risk of causing damage and the objective of this project was to assess the results of the method in such areas.

The location chosen was the City of Maitland and the Vibroseis traverse was sited to straddle the city limits and bridge the gap between two previous conventional seismic traverses which could not otherwise have been tied together.

Programme

The location of the traverse is shown on the Locality Map, Enclosure No. 77. The line passed through the most heavily built-up areas of East Maitland, Maitland and Telarah and largely followed the New England Highway and Maitland By-Pass roads.

A total of six days was worked on this project.

Topography and Survey.

The Built-up Area traverse is shown on the V.P. Location Map, Enclosure No. 78 at the standard 1 inch to 1 mile scale. In addition a map is enclosed, Enclosure No. 79 at the larger scale of 2 and a half inches to 1 mile which shows the location of the traverse superimposed on a detail street map of the City of Maitland and its environs.

The survey method used was the same as that described earlier for the Otway Basin Survey. The elevations varied between 10 and 130 feet above sea level and were based on Bench Marks situated near the traverse. Permanent markers were placed at V.P.s 1892 A, 1877, 1875 and 1865; at these points the elevations were found to be 96, 18, 21 and 72 feet respectively.

Originally the traverse was commenced at V.P. 1893, however the part between V.P. 1893 and V.P. 1890 was later abandoned and the traverse was extended to the south east of V.P. 1889 along the New England Highway. The vibrator points on this extension were then numbered V.P. 1890 A – 1892 A.

The vibrator point locations were plotted with reference to the 1 inch to 1 mile Military Map Sheet. The Hunter District Water Board and the Maitland Gas Works provided reference maps showing the Locations of their respective subterranean mains conduits. With this information it was possible to ensure that the vibrators were not operated directly above the conduits.

Computing.

The elevation datum was Mean Sea Level; elevation corrections only were applied using an elevation velocity of 10,000 feet per second.

The velocity function used to correct for normal move-out was the same as that used on the previous Hawkesbury Sandstone Project in the Sydney Basin. This function proved satisfactory and is given by the formula :-

$$Vi = 12{,}000 + 0.6Z \text{ feet per second.}$$

Where Vi is the instantaneous velocity at a depth of Z feet.

This function was originally derived from the sonic logs of Loder No. 1. and East Maitland No. 1. Wells.

Recording.

The initial recordings were made on the section of line between V.P. 1893 and V.P. 1888 using a simple in-line technique as follows :-

Geophone pattern	-	20 geophones in line over a distance of 400 feet
Vibrator pattern	-	3 vibrators spaced at 30 feet intervals over a length of 400 feet.
No. of sweeps	-	40
Trace interval	-	132 feet
Offset distance	-	1320 - 2640 feet
Sweep frequency	-	20 - 57 cycles per second.

The in-line method was selected as being the most operationally convenient for use in a built up area since the vibrator locations are restricted to one every quarter mile spread length. The sweep frequency was selected on the basis of the record filter of 17 - 52 cycles per second employed during the previous conventional work in the Maitland Area and for this initial test, the vibrator force levels were also reduced to 25% of maximum in order to minimise any possible damage.

The results however showed that the signal to random noise level was much too low; throughout this project recordings were made without stopping or interrupting the traffic and, as a result the random noise level was extremely high.

On this first test, no damage was caused and no complaints were registered by householders and for the remainder of the traverse the vibrator force levels were maintained at maximum except when in the immediate proximity of buildings.

To increase the signal to noise ratio the following transposed technique was then adopted :-

Geophone pattern	-	360 geophones over a length of 400 feet.
Vibrator pattern	-	3 vibrators spaced at 30 feet intervals over a length of 132 feet
No. of sweeps	-	10 per trace
Trace interval	-	132 feet

Profile 1877 West

Profile 1878 East

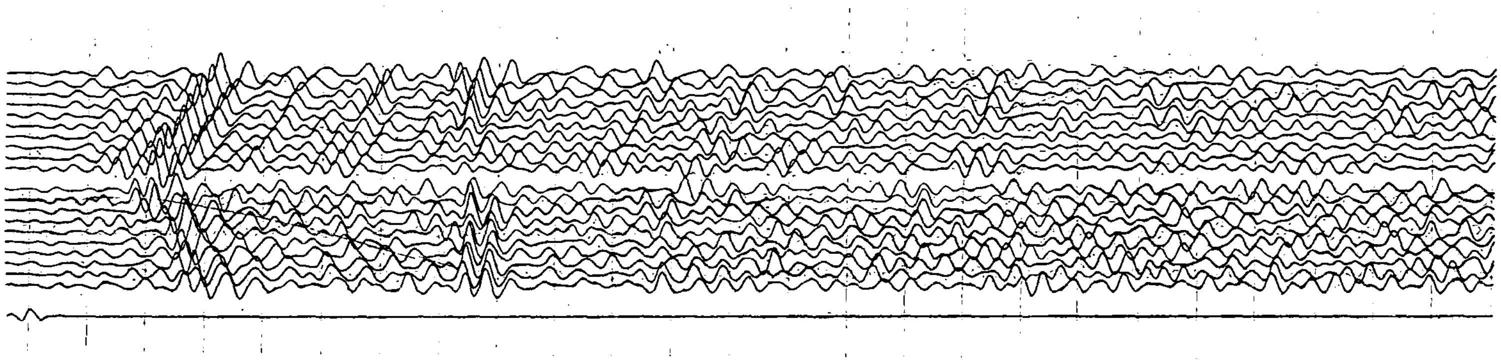


Fig. A. 400 feet Geophone Pattern length Tape 4359

Profile 1873 West

Profile 1874 East

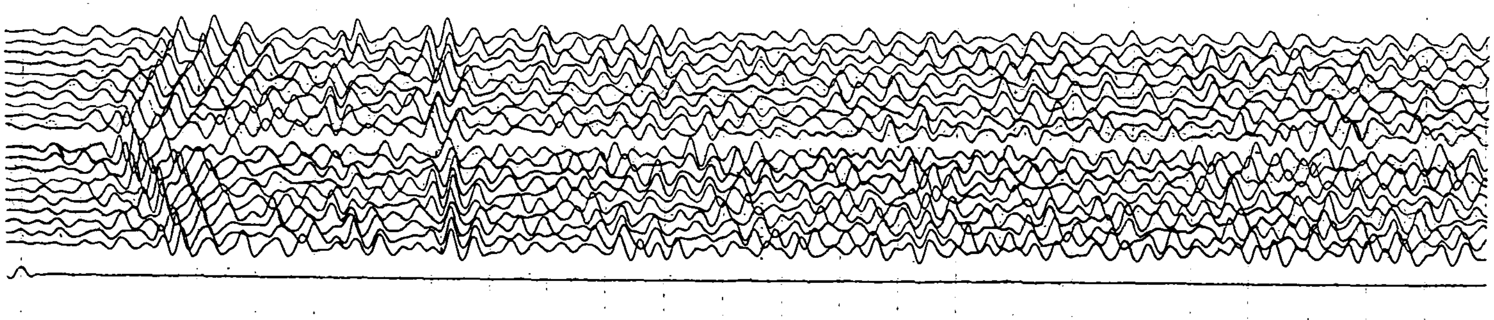


Fig. B. 600 feet Geophone Pattern Length Tape 4364

PLATE (BUILT-UP AREA). I.

Offset distance - 1320-2640 feet

Sweep frequency - 14-40 cycles per second.

The sweep frequency of 10-40 cycles per second was selected due to the presence of considerable high line pick-up; with this sweep 50 cycles per second pick-up is eliminated by the correlation process.

This technique was employed over the section of the traverse between V.P. 1876 and V.P. 1887 and produced very fair quality results. Due to the presence of building and road intersections, it was not always possible to conform to the geophone pattern lengths indicated above and several profiles were produced with shorter geophone pattern lengths and sometimes with the number of geophones reduced. The quality of the results was little affected by these changes in technique. It was found to be preferable to move the geophones as far from the road as possible in order to reduce the traffic noise recorded and in order to achieve this the pattern dimensions were varied.

For the western part of the traverse between V.P. 1865 and V.P. 1875 and for the south-east extension from V.P. 1888 to V.P. 1891A the nominal geophone pattern length was increased to 600 feet and from V.P. 1888 to V.P. 1891A the vibrator pattern length was also increased to 396 feet, in an endeavour to further attenuate the high velocity interference first breaks on the records. The reflection quality however remained essentially unchanged. Plate (Built Up Area) 1 illustrates the reflection quality obtained during this project. Fig. A shows profiles 1878E and 1877W recorded with a geophone pattern length of 400 feet. Fig. B. shows profile 1874E and 1873W recorded with the longer geophone pattern length of 600 feet; in all other respects the field technique remained the same.

Results

The cross section of the Built-Up Area traverse shows a strong horizon extending from V.P. 1891A west as far as V.P. 1869. This horizon is at a time of 0.840 seconds at V.P. 1891A and probably corresponds to the Greta Coal Measures which at East Maitland No. 1. bore are at a depth of 4618 feet. East Maitland No. 1. is located approximately 1 and a half miles east of V.P. 1891A.

Between the eastern end of the traverse and V.P. 1883, this horizon shows approximately 100 milliseconds of south-east dip; further west between V.P. 1883 and V.P. 1869 this dip is reduced and amounts to 20 milliseconds of this part of the line. The continuity of the horizon is lost to the west of V.P. 1869; at this point the horizon has a reflection time of .720 seconds which corresponds to a depth of 4800 feet. However the Greta Coal Measures are known to outcrop in the vicinity of V.P. 1865-1866 and therefore major faulting must occur in the region between V.P. 1866 and V.P. 1869. In this region the section shows some confused dips but no conclusive seismic evidence of faulting other than the abrupt break in continuity of the reflection.

Below the reflection originating at the Greta Coal Measures, a deeper conformable horizon can be followed with intermittent continuity; this horizon is at reflection times of between 1.1 and 1.2 seconds which corresponds to depths of from 8000 - 8800 feet and has not been correlated with any known geological boundary.

SYDNEY BASIN

Conclusions.

The results of the Vibroseis Experimental Survey on the areas of exposed Hawkesbury Sandstone within the Sydney Basin are considered to have delineated the seismic problem previously thought to be inherent to recording on this formation.

It is suggested that the lack of penetration obtained by previous conventional surveys is due to a generation problem associated with poor coupling between the charge and the Hawkesbury Sandstone. The extent of this problem is difficult to establish with certainty but it is supported by the improvement in quality which occurs when the charge is placed in the overlying Wianamatta Shale. This hypothesis implies that the Hawkesbury Sandstone does not attenuate the seismic energy at an abnormally high rate, but that it may not be a good medium for energy generation from a dynamite charge. In contrast it appears that the Vibroseis results are not appreciably affected by the surface formations encountered in this part of the Sydney Basin.

The Vibroseis results demonstrate that by adopting a technique which employs long offsets and large pattern lengths, it is possible to obtain reliable structural data to depths of 11,000 - 12,000 feet. With this technique the best results were obtained when using 20 sweeps per trace and the production rate approached one mile per day.

The use of simpler techniques however produced reliable data down to the level of the Upper Coal Measures and if it was not considered essential to obtain information from the deeper part of the sedimentary section then the production rate could be considerably increased by the adoption of a simpler technique.

The results of the Built-Up Area traverse through the City of Maitland provided good data from the Greta Coal Measures reflector and demonstrated that the Vibroseis method is capable of working successfully within the confines of heavily populated built-up areas and under high traffic density conditions.

Due to the very high random noise level resulting from operation along roads carrying heavy and continuous traffic, the successful recording of seismic data necessitates the compositing of a greater number of samples than would be the case in open country where the ambient noise level would be lower. Hence the geophones were planted as far from the road as possible in order to reduce the recorded traffic noise. An average production rate of 1 and a quarter miles per day was achieved through the built-up area surveyed.

ACKNOWLEDGEMENTS

The information in the Otway Basin sections on Geology and Previous Geophysics has been abstracted from a 'Geophysical Preview Report on the Experimental Vibroseis Survey in the Otway and Sydney Basins' by F.J. Moss. This report is an internal unpublished document of the Bureau of Mineral Resources, Geology and Geophysics.

For the section on the Geology and Previous Geophysics of the Sydney Basin, information has been abstracted from the above mentioned Preview Report and also from the 'East Maitland No. 1. Well Completion Report' for Planet Exploration Co. Pty. Ltd., by D.D. Hamling (Bullock and Associates) and M.G. McKellar (Planet Exploration Co. Pty. Ltd.,) dated August, 1963.

The information in Appendix B, 'Outline of the Vibroseis Method' has been abstracted from a paper presented by M. Barbier to the meeting of the 'Association Francaise des Techniciens du Petrole' in February 1964.

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T. L. Kendall.
Party Chief,
Party 243,
Seismograph Service Ltd.

APPENDICES AND ENCLOSURES

APPENDIX 'A'	STATISTICS
APPENDIX 'B'	OUTLINE OF "VIBROSEIS" METHOD
APPENDIX 'C'	DESCRIPTION OF TECHNICAL EQUIPMENT
APPENDIX 'D'	LIST OF PERSONNEL AND AUTOMATIVE EQUIPMENT

ENCLOSURES

Otway Basin

Part 1. Volcanics Project

No. 1	Locality Map	Volcanics Project	Scale: 4 miles to 1 inch
No. 2	Location Maps	" "	1, 2, & 3 Scale 1 mile to 1 inch
No. 3	Variable Area Section	Volcanics 1	V.P. 96 - 99
No. 4	" " "	"	V.P. 96 - 99 (10 - Fold C.D.P.)
No. 5	" " "	Volcanics 2	V.P. 164 - 199
No. 6	" " "	"	V.P. 88 - 91 (10 - Fold C.D.P.)
No. 7	Variable Area Playback	"	Velocity Profile
No. 8	Velocity Profile	"	$T^2 - X^2$ Plot
No. 9	Variable Area Section	Volcanics 3	V.P. 186 - 199
No. 10.	" " "	"	V.P. 91 - 94 (10 - Fold C.D.P.)
No. 11.	Pretty Hill Velocity Function		Average Velocity-Depth Plot
No. 12	Variable Area Playback	Volcanics 2	Noise Spread No. 1.
No. 13	Volcanics 2	Noise Spread No. 1.	Time-Distance Plot
No. 14.	"	" " "	Response-Wave No. Plot Response-Frequency Plot Wave No. - Frequency Plot
No. 15	Variable Area Playback	Volcanics 2	Noise Spread No. 2
No. 16	Volcanics 2	Noise Spread No. 2	Time-Distance Plot
No. 17	"	" " "	Response-Wave No. Plot Response-Frequency Plot Wave No. - Frequency Plot

No. 18	Variable Area Playback	Volcanics 2	Noise Spread No. 3 (Transposed)
No. 19	" " "	Volcanics 3	Noise Spread
No. 20	Volcanics 3	Noise Spread	Time-Distance Plot
No. 21	" "	" "	Response - Wave No. Plot
			Frequency - Wave No. Plot
No. 22	" "	" "	Frequency - Response Plot
No. 23	Schematic diagram to show sub-surface profiles for Volcanics 2		
No. 24	" " " " " " 3		

Part II Gambier Limestone

No. 25	Locality Map for Gambier Limestone, Sand Dunes and Inter-Dunal Poor Reflection Projects	Scale 4 miles to 1 inch.	
No. 26	Location Map for Gambier Limestone II Project		Scale 1 mile to 1 inch
No. 27	Variable Area Section	Gambier Limestone 2	V.P. 678 - 699 (3 spread offset)
No. 28	" " "	" "	V.P. 689 - 697
No. 29	" " "	" "	V.P. 695 - 699 (One spread offset)
No. 30	" " "	" "	V.P. 695 - 699 (Expanded spread)
No. 31	" " "	" "	V.P. 694 - 697 (2 spread offset)
No. 32	" " "	" "	V.P. 694 - 697 (2 - Fold C.D.P.)
No. 33	" " "	" "	V.P. 793 - 798 (10 - Fold C.D.P.)
No. 34	Variable Area Playback	" "	Noise Spread No. 1
No. 35	Gambier Limestone	Noise Spread No. 1	Time-Distance Plot
No. 36	" "	" "	Response-Wave No. Plot
No. 37	" "	" "	Response-Frequency Plot
No. 38	" "	" "	Wave No. - Frequency Plot
No. 39	Schematic diagram to show sub-surface profiles for Gambier Limestone 2		
No. 40	Location Map	Gambier Limestone 3	Scale: 1 inch to 1 mile
No. 41	Variable Area Section	" "	V.P. 896 - 899
No. 42	" " "	" "	V.P. 893 - 898

Part III Sand Dunes Project

No. 43	Location Maps	Sand Dunes 1 & 2	Scale 1 inch to 1 mile
No. 44	Variable Area Section	Sand Dunes 1	V.P. 994 - 999
No. 45	" " "	" " 2	V.P. 1101 - 1113
No. 46	Variable Area Playback	" " 2	Noise Spread
No. 47	Sand Dunes 2	Noise Spread	Time-Distance Plot
No. 48	Sand Dunes 2	" "	Response-Wave No. Plot Response-Frequency Plot Wave No. - Frequency Plot
No. 49	Variable Area Section	Sand Dunes 3	V.P. 1199 - 1203

Part 1V Inter-Dunal Poor Reflection Project

No. 50 Location Map Inter-Dunal Poor Reflection and Sand Dunes 3 Scale: 1 inch to 1 mile.

No. 51	Variable Area Section	Inter-Dunal Poor Reflection	V.P. 1291 - 1299
No. 52	Variable Area Playback	" " "	Noise Spread
No. 53	Inter-Dunal Poor Reflection	Noise Spread	Time-Distance Plot
No. 54	" " " "	" "	Response-Wave No. Plot Response-Frequency Plot
No. 55	" " " "	" "	Frequency-Wave No. Plot

No. 56 Average Velocity-Depth Plot of Geltwood Beach and Beachport Velocity Functions.

Sydney Basin

Part I Hawkesbury Sandstone-Project

No. 57	Locality Map	Hawkesbury Sandstone 1, 2, 3, & 4.	Scale: 1:250,000
No. 58	Location Map	Hawkesbury Sandstone 1 & 2	Scale : 1 inch to 1 mile
No. 59	Location Map	Hawkesbury Sandstone 3 & 4	Scale : 1 inch to 1 mile
No. 60	Variable Area Section	Hawkesbury Sandstone 1	V.P. 1402 - 1414 (Initial)
No. 61	" " "	" "	V.P. 1407 - 1409 (600 ft. patterns 2 spread offset)
No. 62	" " "	" "	V.P. 1407 - 1409 (600 ft. patterns 3 spread offset)
No. 63	" " "	" "	V.P. 1407 - 1409 (1000 ft. Patterns 2 spread offset)
No. 64	" " "	" "	V.P. 1407 - 1409 (1000 ft. patterns 3 spread offset)

No.	65	Variable Area Playback	Hawkesbury Sandstone 1	Noise Spread
No.	66	Hawkesbury Sandstone 1	Noise Spread	Time-Distance Plot
No.	67	Hawkesbury Sandstone 1	Noise Spread	Response-Frequency Plot Response-Wave No. Plot Frequency-Wave No. Plot
No.	68	" "	Velocity Profile	$Time^2$ - $Distance^2$ Plot
No.	69	Variable Area Section	Hawkesbury Sandstone 2	V.P. 1483 - 1499
No.	70	" " "	" "	V.P. 1484 - 1487
No.	71	" " "	Hawkesbury Sandstone 3	V.P. 1601 - 1606
No.	72	" " "	Hawkesbury Sandstone 4	V.P. 1699 - 1708
No.	73	Hawkesbury Sandstone 4	Line Traverse Map	Scale: 4 inches to 1 mile

No. 74. Average Velocity-Depth Plot for Velocity Function $Vi = 12000 + .6z$

No. 75. Schematic diagram to show sub-surface profiles for Hawkesbury Sandstone 1

No. 76. " " " " " " " 2

Part II Built-Up Area

No.	77	Locality Map	Built-Up Area	Scale 1:250,000
No.	78	Location Map	Built-Up Area	Scale 1 inch to 1 mile
No.	79	Seismic Line Location in Built-Up Area		Scale 2 and a half inches to 1 mile
No.	80	Variable Area Section	Built-Up Area	V.P. 1865 - 1891 A

Enclosures Relevant to the Survey as a Whole

No. 81. Diagram of Field Layout for 10 - Fold C.D.P. (Half and one spread offset)

No. 82. Pattern Response Curves.

APPENDIX 'A'

STATISTICS

Duration of Survey	11th May to 3rd October, 1964
Number of days recording	104½
Number of hours recording	844¼
Average recording hours per day	8.1 hours
No. of days travelling between projects	5½
No. of hours " " "	42¾
Average travelling hours per day between projects	7¾
Number of profiles recorded in line	138
Number of profile recorded transposed	541
Number of profiles single coverage for C.D.P.	199
Total number of profiles	878
Average profiles per recording hour	1.04

APPENDIX B

OUTLINE OF THE VIBROSEIS METHOD

The spectrum of reflected energy that appears on a seismic record includes all the frequencies, emanating from the source, which the earth allows to pass; a reflection therefore may be defined by its spectrum and by the phase relationship between the different frequencies. Any method of injecting a band of frequencies into the earth with a known phase relationship is a possible exploration method. As the earth reaction is no different whether the component frequencies are transmitted simultaneously, as in the case of conventional or pulsed surface methods, or consecutively, as with the Vibroseis method, the records obtained by the two methods are virtually the same.

The basis of the 'Vibroseis' system is the application of frequencies consecutively, the received signals are then subjected to a continuous correlation process which restores them to the same kind of pulse that would have been obtained if the frequencies had been transmitted simultaneously.

The final result obtained from the Vibroseis system is a normal seismic record, the various earth paths recorded are exactly the same as those of the impulse method. However the field technique used to obtain this final result differs considerably from conventional seismic techniques.

Three hydraulic vibrator units are operated synchronously and inject, into the earth, a signal of constantly varying frequency. This constantly swept signal has a duration of approximately 7 seconds and is called a 'sweep'. The sweep is transmitted by radio from the recording truck.

Three different field layouts are currently used. The first called the in-line method, uses two spreads, each consisting of ten traces, one on either side of the vibrator point. This layout is comparable to the conventional straddle-spread technique.

In the second layout, called the 'transposed' method, the geophones are grouped into two arrays and the vibrators vibrate at each of the trace intervals along the spread. The name applied to this method is due to the transposition of the vibrators and geophones from the conventional layout of the in-line method.

In both methods described above the ten sub-surface points covered by one ten trace spread is called a 'profile'. Due to the use of different offset distances between the vibrators and geophones, the sub-surface location of a profile can bear a different relationship to the vibrator points from which it was produced. A profile is designated by the number of the vibrator point below which it lies and the direction in which it extends.

The third method is the common depth point system. This combines, so far as the field layout is concerned, the two methods described above. The geophones are laid out as for the in-line method and the vibrators vibrate at each interval as for the transposed method. By moving both geophones and vibrators one trace at a time, a continuous 10 fold common depth point coverage is achieved.

Careful consideration has to be given to the attenuation of horizontally travelling interference. This may represent surface waves or shallow refractions and unlike wind noise is the same form as the transmitted sweep and is therefore rigorously detected by the correlation process. To improve the amplitude ratio of the reflected energy over that of the horizontally travelling interference, the same methods are used as in pulse techniques. They are the offset distance of the spread from the source and, the use of geophone and vibrator patterns as spatial filters.

The optimum length of source and geophone patterns is determined by the wave length of the surface arrivals to be attenuated. To take an extreme case, using a sweep of 10-40 cps. and a high velocity near-surface layer of 10,000 feet per second, a maximum wave length of approximately 1000 feet will be obtained and in consequence the patterns could be 1000 feet long. Due to the large number of samples in the patterns they are always considered for the purpose of establishing their spatial filtering characteristics, as continuous source and detector patterns.

However, in order to satisfy the maximum allowable pattern length which will not attenuate the shallowest reflection, the resultant pattern length may, by necessity, be a compromise.

The pattern length is also used to maintain the amplitudes recorded at the beginning of the record and the amplitude of the deepest horizon within the recording range of the equipment. If a high amplitude shallow reflection or refraction is present, the amplifier gains are set so that this reflection is recorded at 100% modulation but in doing so the sensitivity of the amplifiers may be insufficient to enable the deepest reflection to be recorded. To overcome this firstly the offset and then the source and geophone pattern lengths are increased to attenuate the early arrivals with respect to the deeper ones.

The frequencies of the sweeps used are all contained in the band 10-120 cycles per second and the object is to inject into the earth all the frequencies which contribute appreciably to reflection resolution and not to use frequencies which are rapidly attenuated or those which are predominant in the horizontally travelling interference. If there is no penetration problem, the widest possible band is used since it matters less if time is spent in transmitting frequencies playing only a small part in the reflection quality; if, on the other hand, the area is a difficult one, a narrow band is usually used centred on the frequency giving the best response in order to be sure that all the frequencies transmitted fully contribute in obtaining reflections. More commonly however, the problem existing in a difficult area is one of obtaining a good ratio between the reflected signal and the coherent noise. In this case the choice of sweep frequency may depend primarily on eliminating frequencies contained in the noise rather than enhancing those contained in the reflections.

APPENDIX 'C'

DESCRIPTION OF THE VIBROSEIS EQUIPMENT

Vibrators

The servo hydraulic vibrator comprises basically a two-way hydraulic piston driven by a fast response servo valve which is controlled by any given electrical signal. The control sweep signal is received at each vibrator by a frequency modulated radio transceiver; several vibrators may be operated simultaneously in synchronism.

The system develops a constant peak force over the seismic frequency spectrum which is the product of the hydraulic pressure and piston area. As the energising control sweep signal is sinusoidal, the available peak force is similarly sinusoidal and is directly proportional to the base plate mass, to the displacement of the base plate and to the square of the frequency of the vibration.

Each vibrator is capable of exerting a peak force of 10,000 lbs.

The vibrators are mounted on Ford T850 four wheel drive vehicles fitted with automatic fluid drive gearboxes which permits rapid movement between vibration points and allows a large number of independent sources of seismic energy to be obtained quickly.

The vibrator mass is raised and lowered hydraulically by remote control from the driving cab; during vibration, the whole rear end of the vehicle is raised off the ground onto the vibrator mass assembly.

The hydraulic energy is derived from a high pressure pump driven by an auxiliary engine.

Recording Instruments

The field instruments consist essentially of :-

20 seismic Amplifiers SSL Type AAS
1 Control Sweep Amplifier
1 Decatrack 2-Drum Magnetic Recorder
1 Visual Monitor Display Unit.
1 Frequency Modulated Radio Transceiver
2000 Geophones Type HS-J 14 cps.

The control signal is sinusoidal with the frequency changing continuously throughout the duration of the 7 - second sweep so that no part is repeated, i.e. the signal is unique.

Various control signals are available covering different frequency bands within the seismic frequency spectrum 10-120 cycles per second. The selected control signal is recorded onto the field tape from a 'master' tape and transmitted to the vibrators by radio after amplification in the sweep amplifier.

The geophone signal is amplified without AVC and recorded on the Decatrack magnetic tape recorder. This recorder contains two drums revolving at a speed of 13 seconds per revolution. Each drum has 20 signal channels.

Basically the Decatrack recorder consists of a bank of movable narrow track width record heads, a bank of fixed full track width pick up heads and a further bank of narrow track width record heads. The narrow heads each record a track one tenth of the width of a full track and are moved in a lateral direction after each recording. By this means 10 recording tracks can be built up on each channel on the first drum.

Compositing of the first 10 recordings is accomplished by the bank of fixed full track width heads. These heads are situated in line circumferentially with the record heads and each head scans all 10 narrow tracks simultaneously. The information picked up by these heads is passed to the transcribe section of the amplifiers, the output of which is routed to the narrow transcribe heads on the second drum. These narrow transcribe heads are also indexed laterally after each transmission and thus 10 recordings are transcribed at a time and each transcription is recorded on a narrow track giving an overall range of 100 recordings on each channel of the second drum field tape.

Playback Equipment.

The playback equipment comprises :-

1 Twin Drum Magnetic Recorder

1 Correlator Unit

1 Corrector Unit

1 Variable Area Cross Section Recorder S. S. L. .Type VAX
1 Translator Unit comprising of a playback Amplifier
and Paper Recorder Oscillograph.

The playback magnetic recorder has two co-axial drums, one revolving at the speed of the recording truck magnetic recorder of 13 seconds per revolution and one revolving at the standard Techno speed of 6.5 seconds per revolution.

The uncorrelated 13 second 'field' tape produced in the recording truck is placed on the slow speed drum of the playback recorder and 20 signal channels are selected sequentially for correlation and the application of dynamic and static corrections.

The output of the correlator is corrected both statically and dynamically and is then re-recorded through an unfiltered recording amplifier on a fast speed drum of the playback recorder as a 'read-out' tape at the standard Techno speed.

The information on this read-out tape is in the 'conventional' form and compatible with normal conventional playback systems.

Monitor paper recordings are produced during the correlation process by the translator unit and the read-out tape is also played back through the VAX recorder to produce continuous fully corrected variable area cross section on film.

For common depth point work, the field tapes are correlated and corrected in the usual way. The read-out tapes thus produced have the information for each sub-surface point played back, by the magnetic reproducer in the recording truck, and recorded onto one decatrack position. From the next read-out tape the second sample from the same sub-surface is recorded on the adjacent decatrack position. In this way by changing the read-out tapes, ten samples, from different offsets, are added into one trace thus providing 10-fold stacked traces on the final read-out tape.

APPENDIX 'D'

List of Key Personnel

Supervision	K. L. M. Welsh
Party Chief	T. L. Kendall
Chief Computor	L. Gray
Computor	V. Djokic
Correlator Operator	M. Covil
Observer	D. G. Maclean
Assistant Observer	R. Quick
Vibroseis Technician	J. D. Murphy
Vibrator Mechanic	F. Cushion
Vehicle Mechanic	J. Matthews
Surveyor	P. Mills
Party Manager	R. Keen
Vibrator Operators	R. Addie
	G. Killa
	R. Platzl

List of Automative Equipment

One Recording Truck	-	-	Bedford 4 x 4
One Geophone Truck	-	-	Bedford 4 x 4
Four Vibrator Trucks	-	-	Ford T 850 6 x 4
One Supply Truck	-	-	Bedford 4 x 4
One Survey Land Rover	-	-	4 x 4
One Cable Land Rover	-	-	4 x 4
One General Purpose Land Rover		-	4 x 4
One Holden	-	-	Party Chief.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

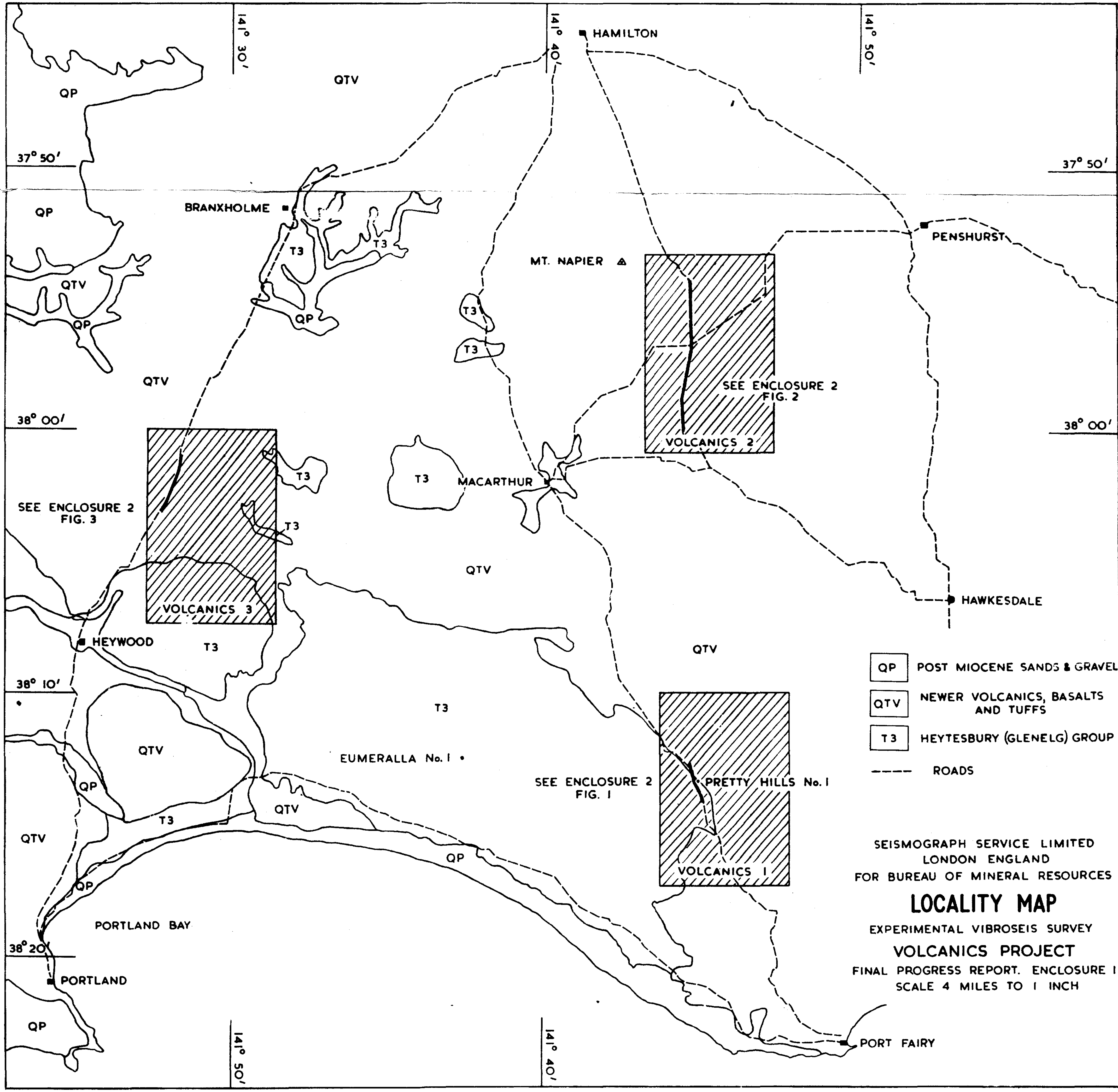
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

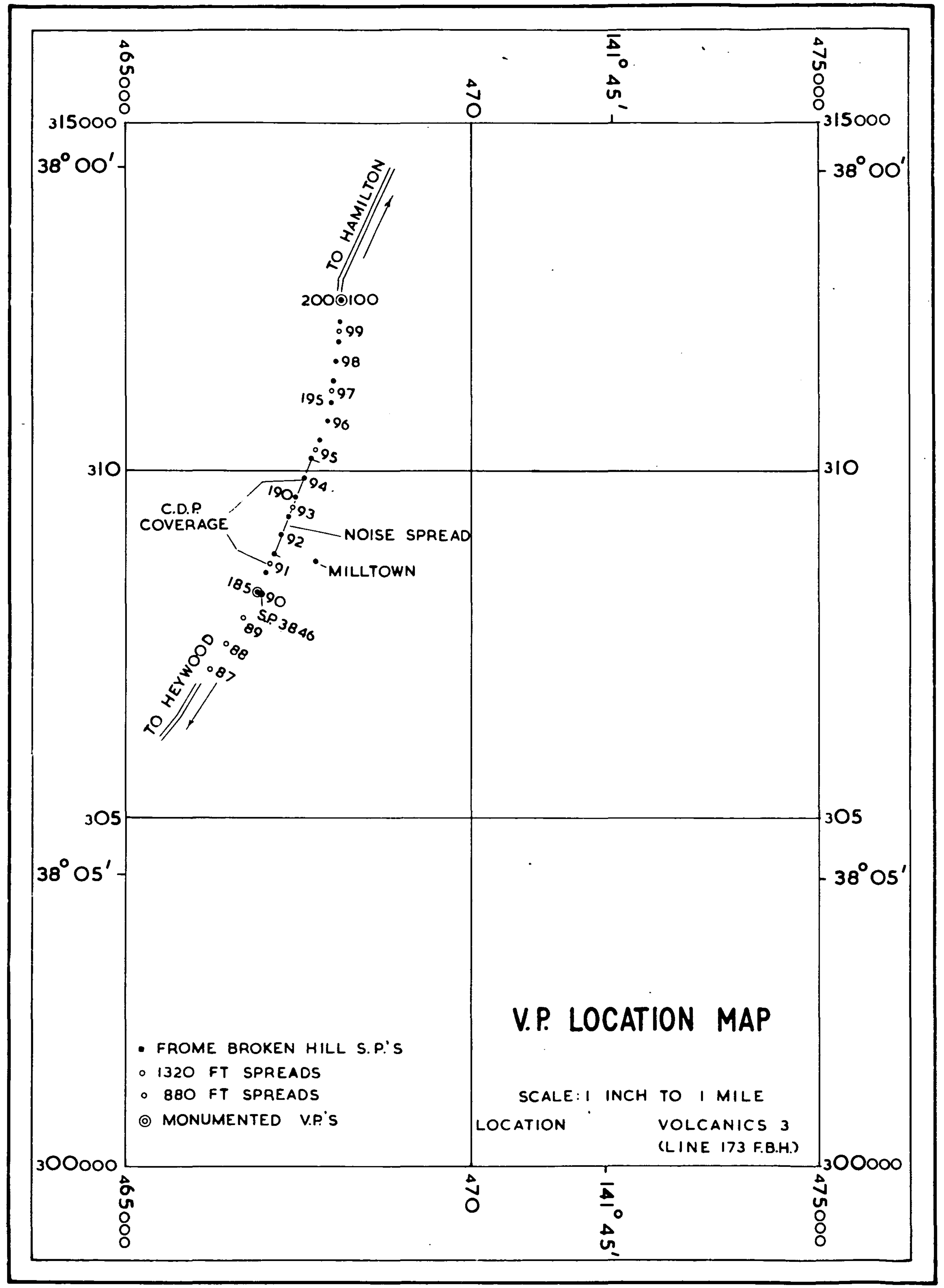
RECORD No. 1965/198

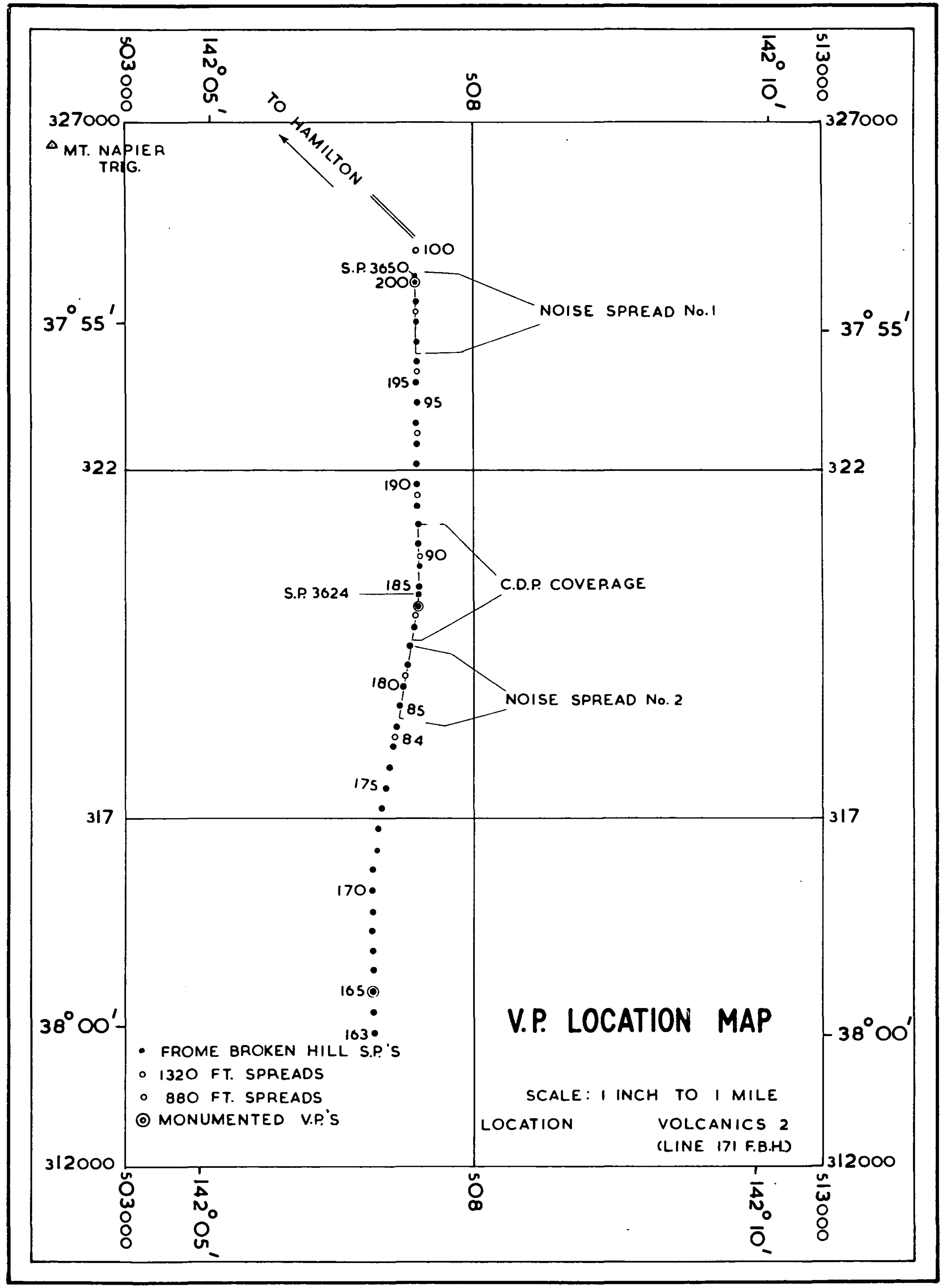
OTWAY AND SYDNEY BASINS EXPERIMENTAL "VIBROSEIS" SURVEY, 1964

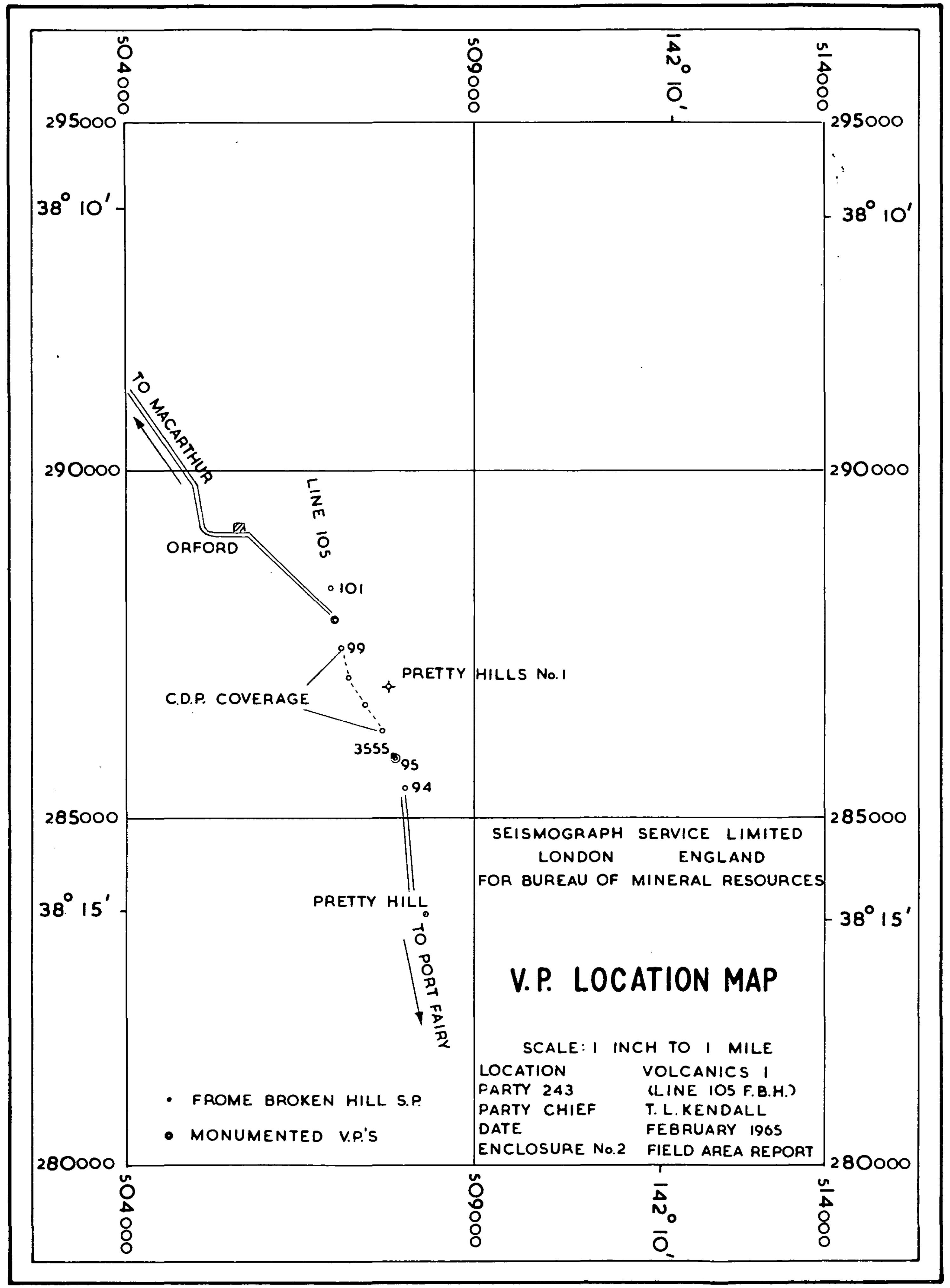
ENCLOSURES
to the
FINAL FIELD AREA REPORT
on the
EXPERIMENTAL VIBROSEIS SEISMIC SURVEY,
OTWAY AND SYDNEY BASINS.

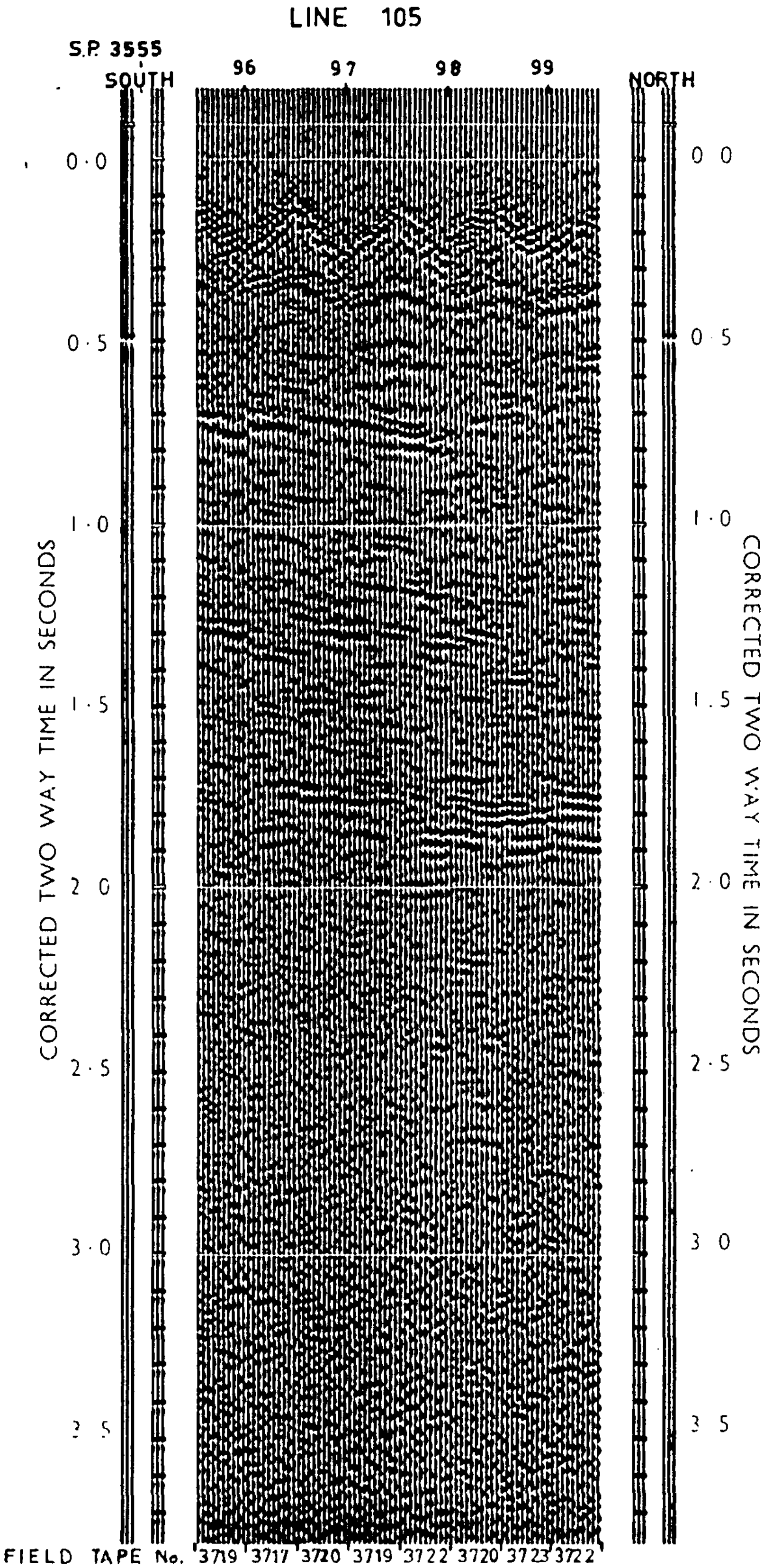
PLATE 1


141° 30′
141° 40′
141° 50′
HAMILTON
QTV
QP
37° 50′
BRANXHOLME
T3
MT. NAPIER
PENSHURST
SEE ENCLOSURE 2
FIG. 2
VOLCANICS 2
38° 00′
SEE ENCLOSURE 2
FIG. 3
MACARTHUR
VOLCANICS 3
HAWKESDALE
HEYWOOD
38° 10′
EUMERALLA No. 1
SEE ENCLOSURE 2
FIG. 1
PRETTY HILLS No. 1
VOLCANICS 1
PORTLAND BAY
38° 20′
PORTLAND
PORT FAIRY
QP POST MIOCENE SANDS & GRAVEL
QTV NEWER VOLCANICS, BASALTS AND TUFFS
T3 HEYTESBURY (GLENELG) GROUP
ROADS
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
LOCALITY MAP
EXPERIMENTAL VIBROSEIS SURVEY
VOLCANICS PROJECT
FINAL PROGRESS REPORT. ENCLOSURE 1
SCALE 4 MILES TO 1 INCH


V.P. LOCATION MAP
SCALE: I INCH TO I MILE
LOCATION VOLCANICS 3 (LINE 173 F.B.H.)
• FROME BROKEN HILL S.P.'S
○ 1320 FT SPREADS
○ 880 FT SPREADS
◎ MONUMENTED V.P.'S
TO HAMILTON
TO HEYWOOD
C.D.P. COVERAGE
NOISE SPREAD
MILLTOWN
S.P. 3846
465000
470
141° 45'
475000
315000
310
305
300000
38° 00'
38° 05'


V.P. LOCATION MAP
SCALE: I INCH TO I MILE
LOCATION VOLCANICS 2 (LINE 171 F.B.H.)
• FROME BROKEN HILL S.P.'S
○ 1320 FT. SPREADS
○ 880 FT. SPREADS
◎ MONUMENTED V.P.'S
MT. NAPIER TRIG.
TO HAMILTON
S.P. 3650
NOISE SPREAD No. 1
C.D.P. COVERAGE
S.P. 3624
NOISE SPREAD No. 2
503000
142° 05'
508
142° 10'
513000
327000
322
317
312000
37° 55'
38° 00'


V.P. LOCATION MAP
SCALE: I INCH TO I MILE
LOCATION VOLCANICS I
PARTY 243 (LINE 105 F.B.H.)
PARTY CHIEF T. L. KENDALL
DATE FEBRUARY 1965
ENCLOSURE No. 2 FIELD AREA REPORT
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
• FROME BROKEN HILL S.P.
● MONUMENTED V.P.'S
TO MACARTHUR
ORFORD
LINE 105
PRETTY HILLS No. 1
C.D.P. COVERAGE
3555
PRETTY HILL
TO PORT FAIRY
504000
509000
142° 10'
514000
295000
290000
285000
280000
38° 10'
38° 15'



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
FOR BUREAU OF MINERAL RESOURCES

VOLCANICS 1

LINE 105 S.P'S. 96 - 99

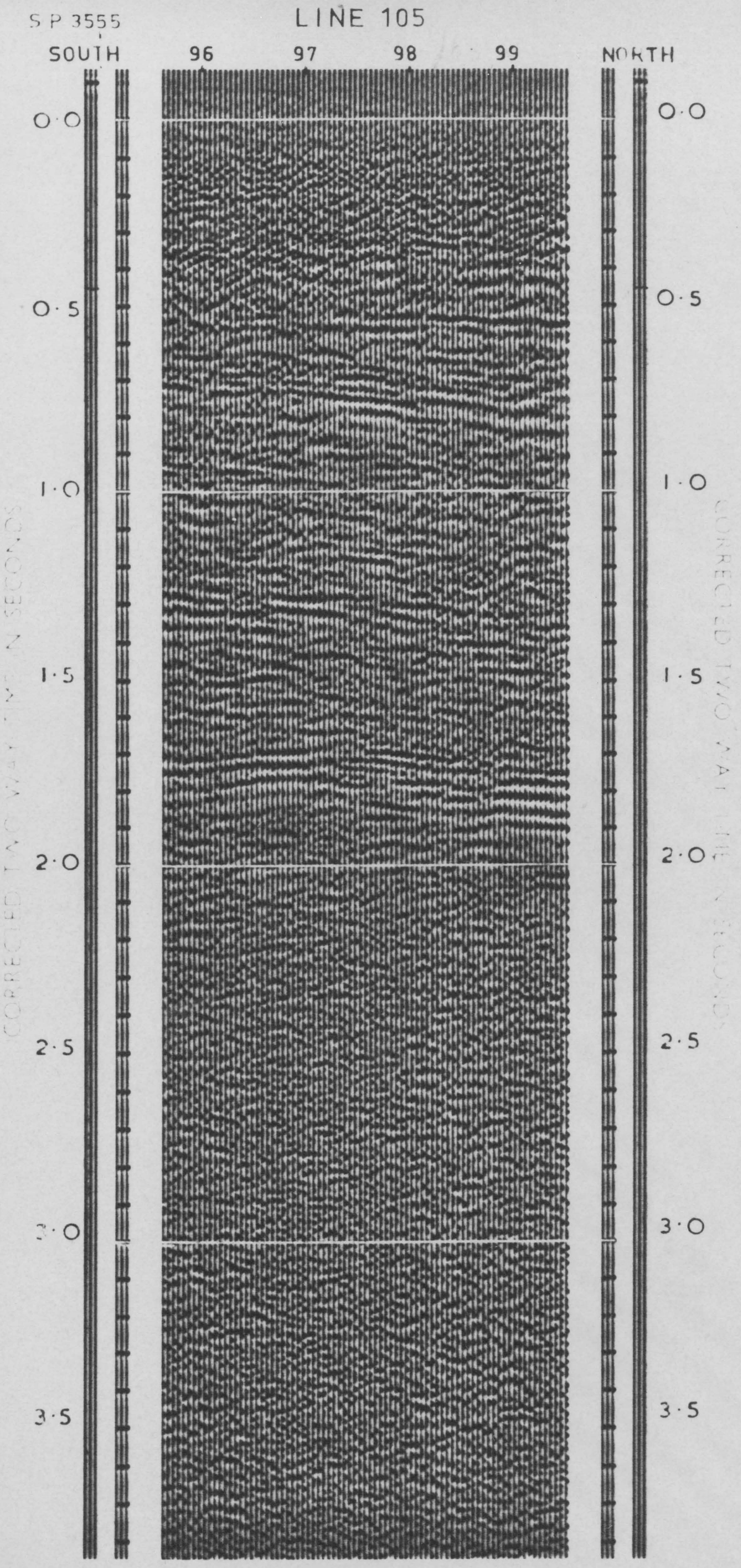
VELOCITY DISTRIBUTION	PRETTY HILLS No 1
WEATHERING VELOCITY (Vw)	2000 FT. SEC.
HORIZONTAL VELOCITY (Vh)	—
ELEVATION VELOCITY (Ve)	6000 FT. SEC.
WEATHERING METHOD	—
DATUM: M.S.L.	TRACE INTERVAL: 132'
HORIZONTAL SCALE	1": 2400'
OFFSET DISTANCE	1386' - 2574'
PLAYBACK FILTER	14 - 60
MIXING: UNMIXED	No. OF SWEEPS: 10
No. OF VIBRATORS.	3.
SWEEP FREQUENCY	14 - 57
TYPE OF PROFILING	TRANSPOSED

VIBRATOR PATTERN:
396' IN LINE

GEOPHONE PATTERN

400' × 198' RECTANGLE OF
400 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 3	FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIA[illegible] AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

VOLCANICS 1

LINE 105	S P'S. 96 — 99
VELOCITY DISTRIBUTION	PRETTY HILLS No 1
WEATHERING VELOCITY (V_w)	2000 F/SEC
HORIZONTAL VELOCITY (V_h)	—
ELEVATION VELOCITY (V_e)	6000 F/SEC
WEATHERING METHOD	—
HORIZONTAL SCALE 1" : 2400'	DATUM M.S.L.
TYPE OF PROFILING	10-FOLD C.D.P.
TRACE INTERVAL	132'
OFFSET DISTANCE	1386' – 3894'
No. AND TYPE OF VIBRATORS	3 – 2
SWEEP FREQUENCY 14 – 57	No OF SWEEPS 10
PLAYBACK FILTER	14 – 60
MIXING	NIL

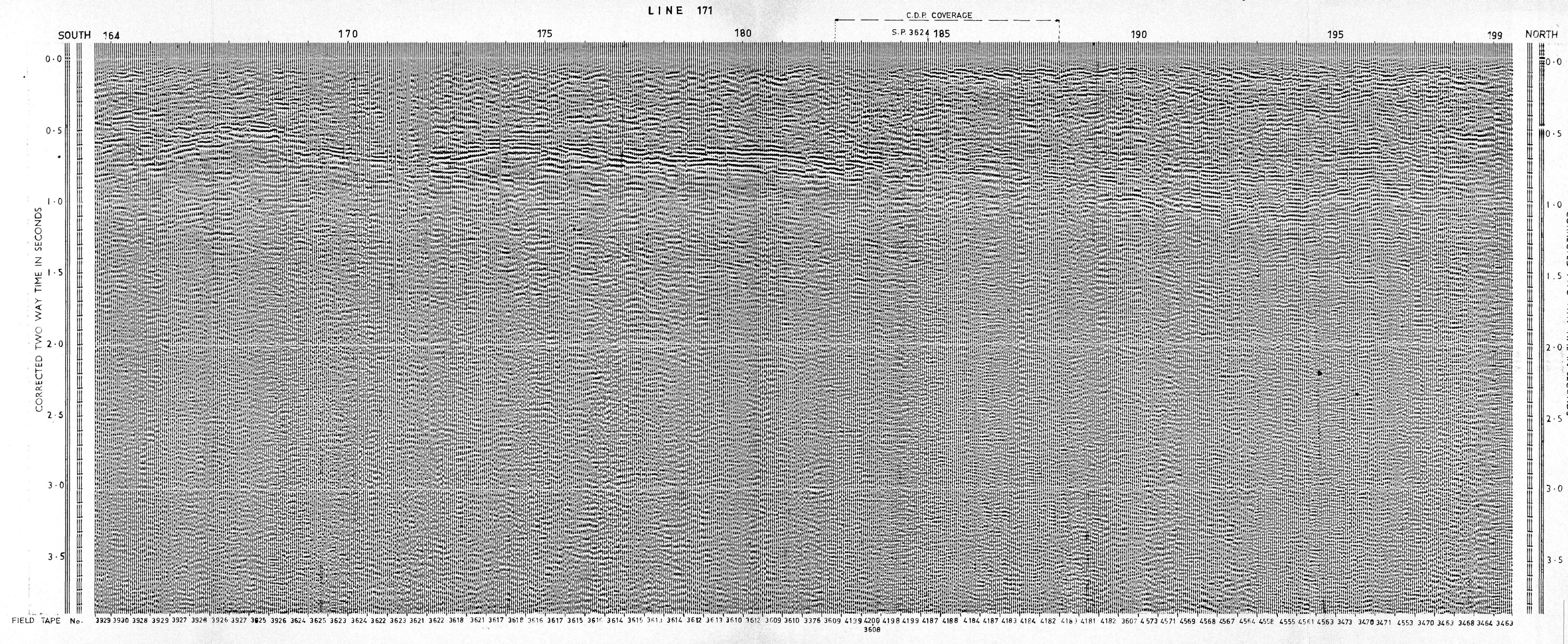
VIBRATOR PATTERN:

264' X 100'

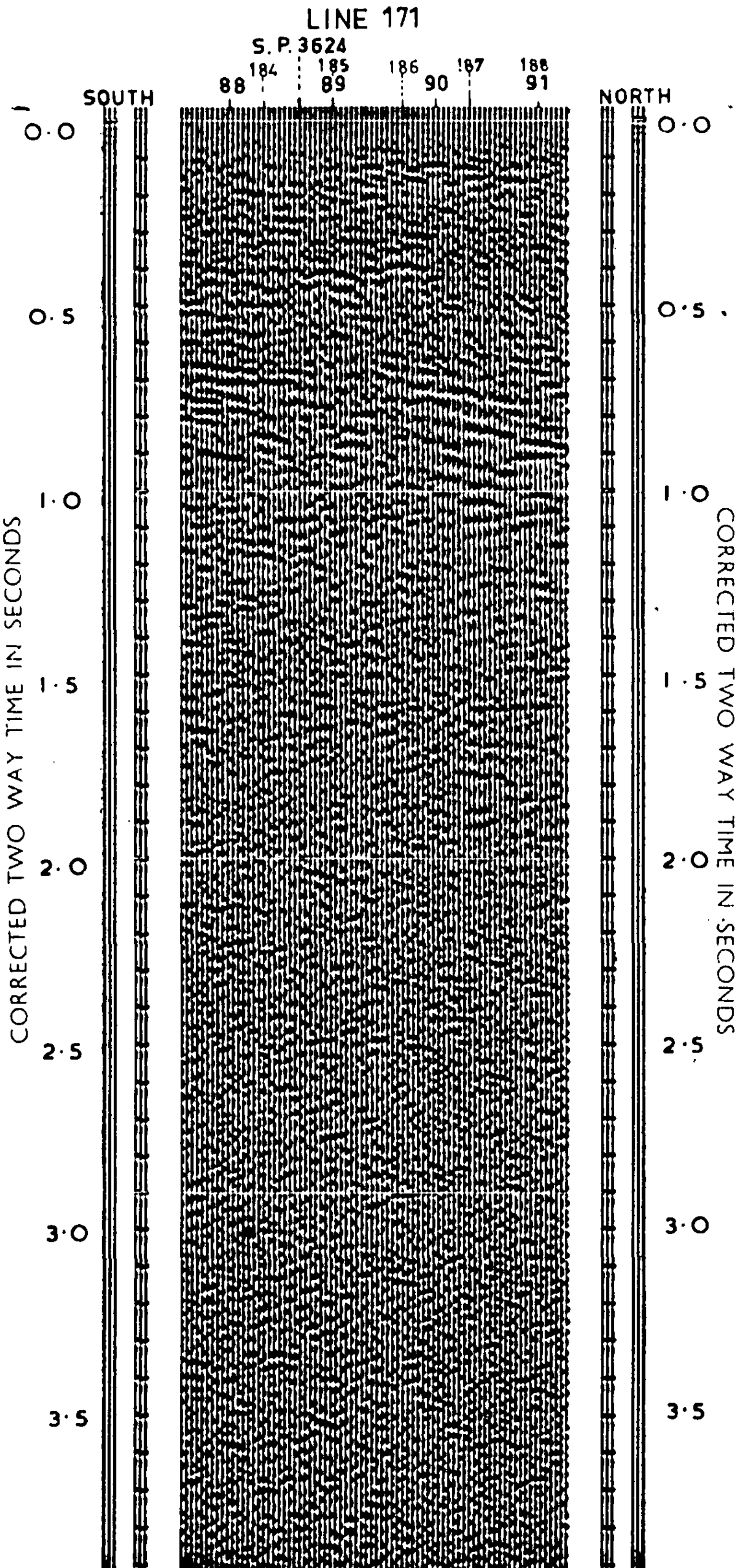
GEOPHONE PATTERN:

264' ALONG LINE WITH 40 GEOPHONES PER TRACE

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 4	FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED LONDON ENGLAND	
VARIABLE AREA CROSS-SECTION VIBROSEIS® FOR BUREAU OF MINERAL RESOURCES **VOLCANICS 2**	
LINE 171 S.P.'S. 164 — 199	
VELOCITY DISTRIBUTION	PRETTY HILLS No.1
WEATHERING VELOCITY (V_w)	2000 F/SEC
HORIZONTAL VELOCITY (V_h)	—
ELEVATION VELOCITY (V_e)	6000 F/SEC
WEATHERING METHOD	—
HORIZONTAL SCALE 1" = 1600'	DATUM M.S.L. +500'
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	88'
OFFSET DISTANCE	
No. AND TYPE OF VIBRATORS	3 OR 2
SWEEP FREQUENCY	No. OF SWEEPS 10-20
PLAYBACK FILTER	20 — 60
MIXING	3/2 COMPOSITED
VIBRATOR PATTERN: SEE SCHEMATIC DIAGRAM	
GEOPHONE PATTERN: SEE SCHEMATIC DIAGRAM	
PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No.5	FIELD AREA REPORT



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LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
FOR BUREAU OF MINERAL RESOURCES

VOLCANICS 2

LINE 171 S P'S. 88 - 91

VELOCITY DISTRIBUTION	PRETTY HILLS No1
WEATHERING VELOCITY (Vw)	2000 FT. SEC.
HORIZONTAL VELOCITY (Vh)	—
ELEVATION VELOCITY (Ve)	6000 FT. SEC.
WEATHERING METHOD	—
DATUM M.S.L. + 500'	TRACE INT. 132'
HORIZONTAL SCALE	1" : 2400'
OFFSET DISTANCE	726' — 3234'
PLAYBACK FILTER	20 - 60
MIXING UNMIXED	No. OF SWEEPS 10
No. OF VIBRATORS.	2.
SWEEP FREQUENCY	20 - 57
TYPE OF PROFILING	10-FOLD C.D.P.

VIBRATOR PATTERN:

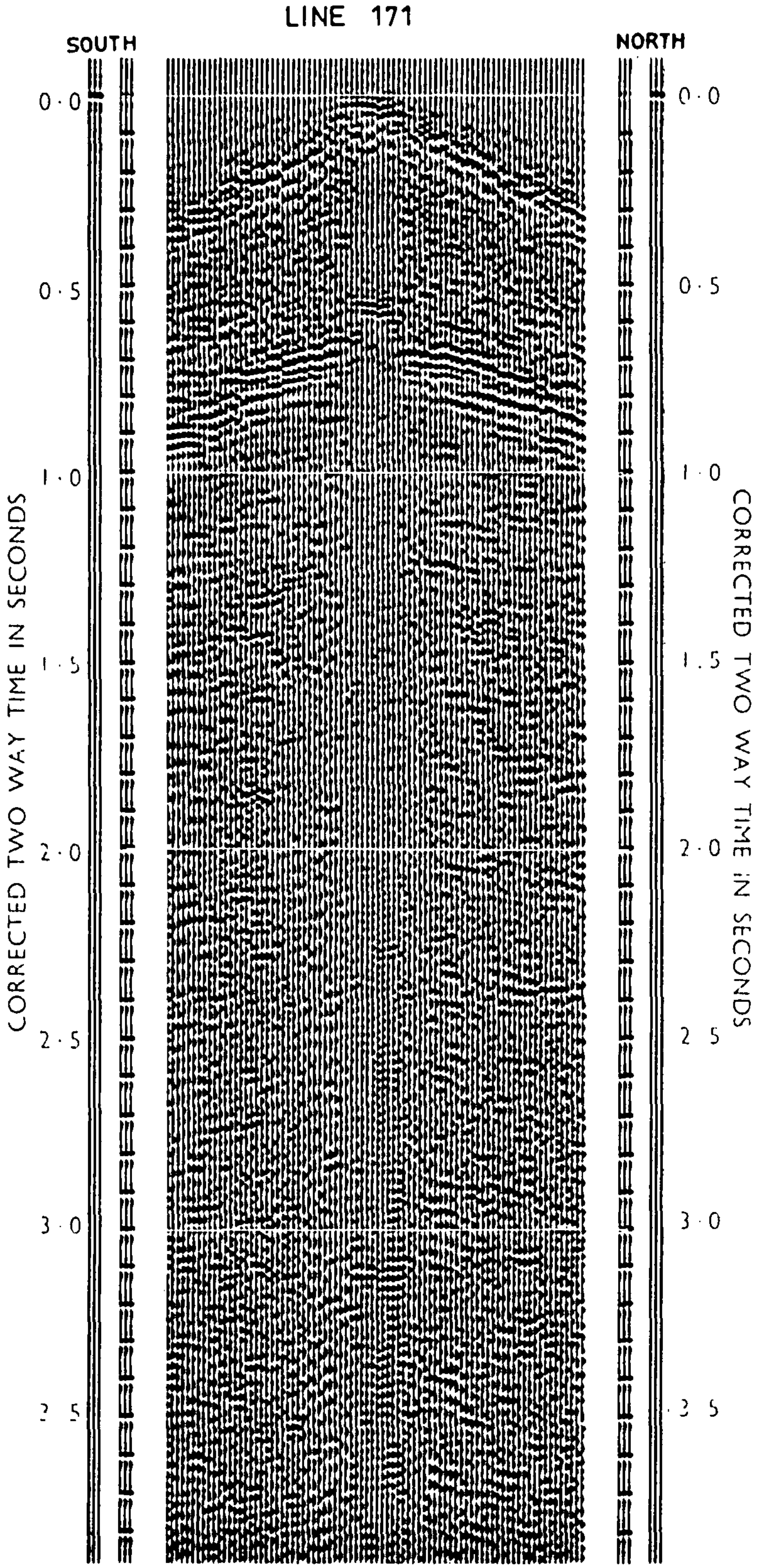
264' IN LINE WITH 132' SPACING

GEOPHONE PATTERN:

264' ALONG LINE WITH

40 GEOPHONES PER TRACE

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 6	FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

VELOCITY PROFILE

LINE 171	SP'S. –
VELOCITY DISTRIBUTION	–
WEATHERING VELOCITY (V_w)	2000 FT. SEC.
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	6000 FT. SEC.
WEATHERING METHOD	–
HORIZONTAL SCALE 1" = 3000'	DATUM M.S.L. + 500'
TYPE OF PROFILING	IN LINE
GEOPHONE INTERVAL	88'
OFFSET DISTANCE	66' - 3480'
No. AND TYPE OF VIBRATORS	
SWEEP FREQUENCY 20 — 57	No. OF SWEEPS 80
PLAYBACK FILTER	20 - 60
MIXING UNMIXED	

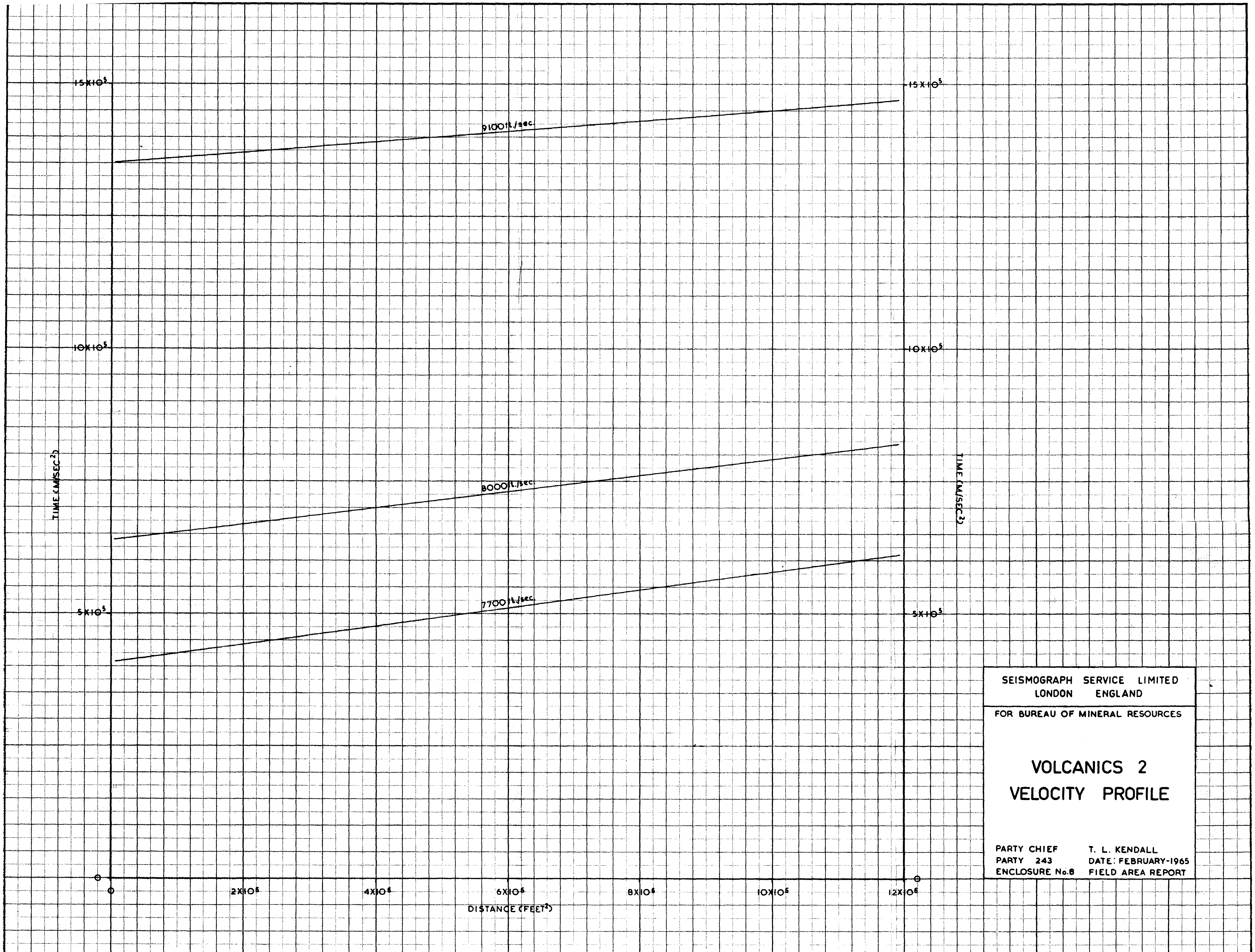
VIBRATOR PATTERN:
400' IN LINE WITH 200' SPACING

COMMON SUBSURFACE — PROFILE 180 N

GEOPHONE PATTERN:
400' IN LINE

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 7	FIELD AREA REPORT

® A TRADE MARK CONTINENTAL OIL CO.

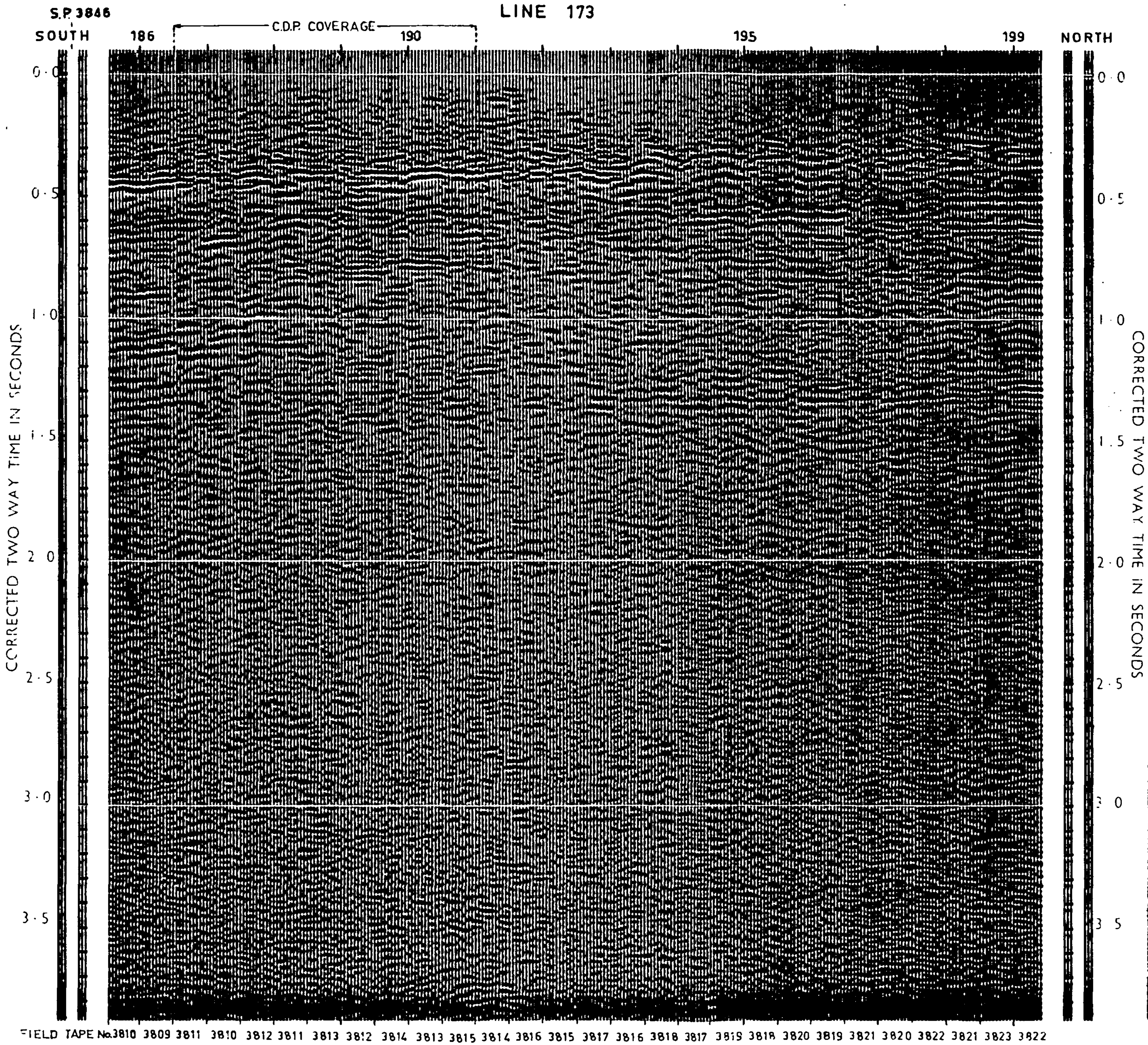


SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

VOLCANICS 2
VELOCITY PROFILE

PARTY CHIEF T. L. KENDALL
PARTY 243 DATE: FEBRUARY-1965
ENCLOSURE No.8 FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION, VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

VOLCANICS 3

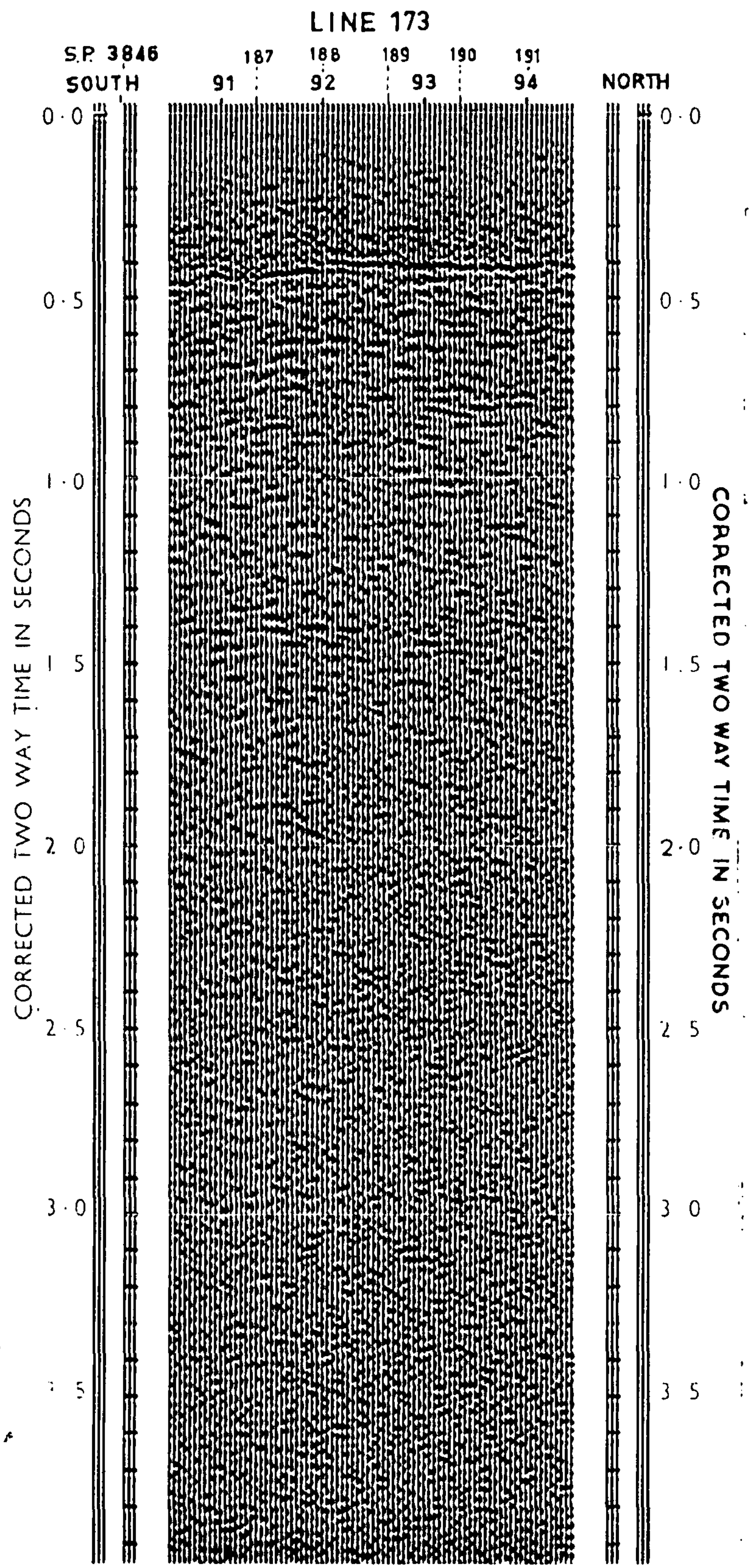
LINE 173	S.P'S. 186 — 199
VELOCITY DISTRIBUTION	PRETTY HILLS No.1
WEATHERING VELOCITY (V_w)	2000 FT. SEC.
HORIZONTAL VELOCITY (V_h)	—
ELEVATION VELOCITY (V_e)	6000 FT. SEC.
WEATHERING METHOD	—
HORIZONTAL SCALE 1:1600	DATUM M.S.L. + 300'
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	88'
OFFSET DISTANCE	924'—1714'
No. AND TYPE OF VIBRATORS	3 OR 2
SWEEP FREQUENCY 20-57	No. OF SWEEPS 10:20
PLAYBACK FILTER	20 — 60
MIXING	3/2 COMPOSITED

VIBRATOR PATTERN:
400' IN LINE

GEOPHONE PATTERN:
400' X 200' RECTANGLE OF 350 GEOPHONES

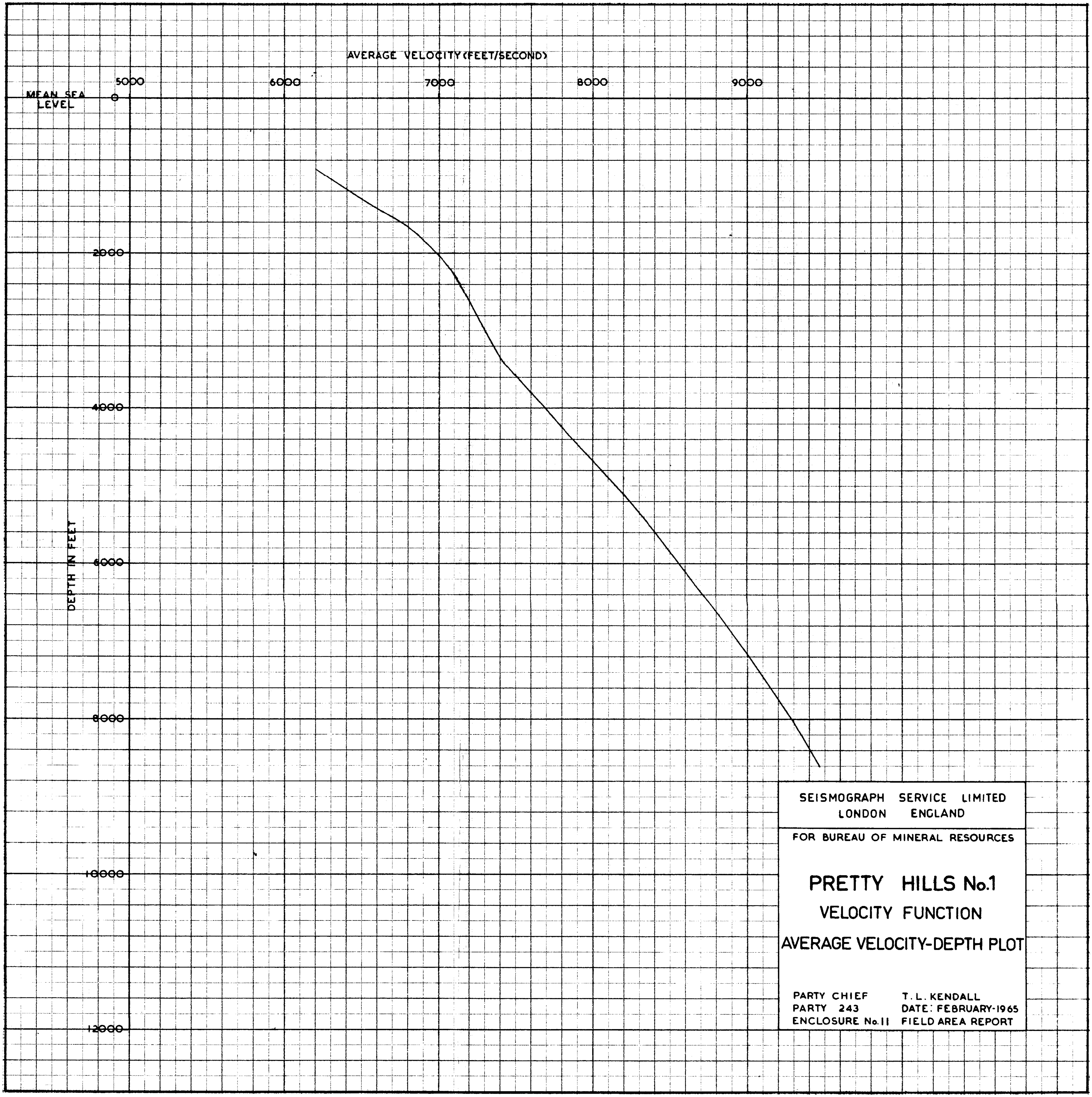
PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 9	FIELD AREA REPORT

®A TRADE MARK CONTINENTAL OIL CO



SEISMOGRAPH SERVICE LIMITED LONDON ENGLAND	
VARIABLE AREA CROSS-SECTION VIBROSEIS® FOR BUREAU OF MINERAL RESOURCES	
VOLCANICS 3	
LINE 173	S.P.'S. 91–94
VELOCITY DISTRIBUTION	PRETTY HILLS No.1
WEATHERING VELOCITY(Vw)	2000 FT. SEC.
HORIZONTAL VELOCITY(Vh)	–
ELEVATION VELOCITY (Ve)	6000 FT. SEC.
WEATHERING METHOD	–
HORIZONTAL SCALE 1":2400'	DATUM M.S.L.+300'
TYPE OF PROFILING	10-FOLD C.D.P.
TRACE INTERVAL	132'
OFFSET DISTANCE	726' — 3234'
No.AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 20–57	No.OF SWEEPS 10
PLAYBACK FILTER	20 – 60
MIXING	–
VIBRATOR PATTERN: 264' IN LINE	
GEOPHONE PATTERN: 40 GEOPHONES SPACED OVER 264' ALONG THE LINE	
PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No.10	FIELD AREA REPORT

®A TRADE MARK CONTINENTAL OIL CO.



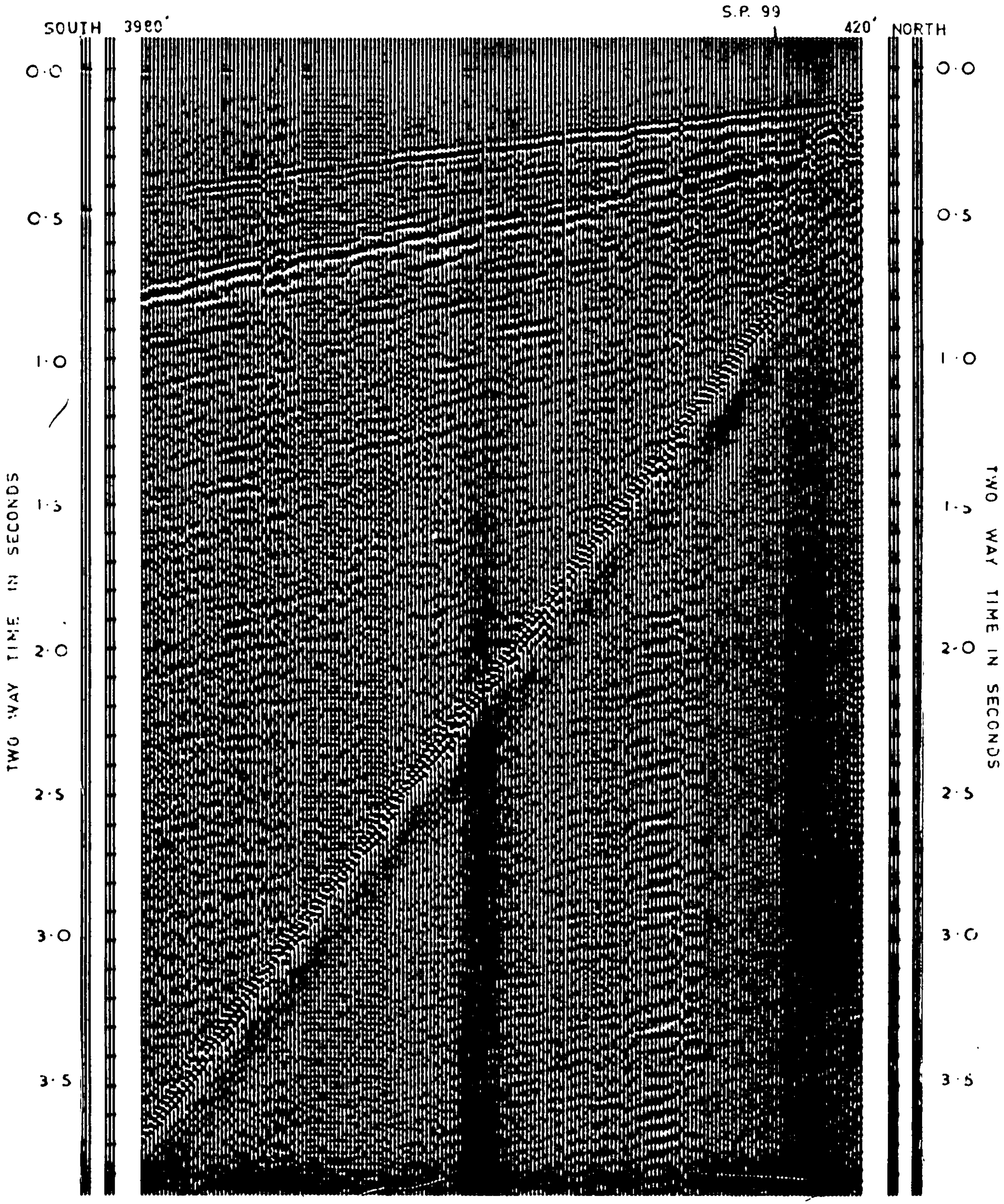
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

PRETTY HILLS No.1
VELOCITY FUNCTION
AVERAGE VELOCITY-DEPTH PLOT

PARTY CHIEF T. L. KENDALL
PARTY 243 DATE: FEBRUARY-1965
ENCLOSURE No. 11 FIELD AREA REPORT

LINE 171



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
FOR BUREAU OF MINERAL RESOURCES

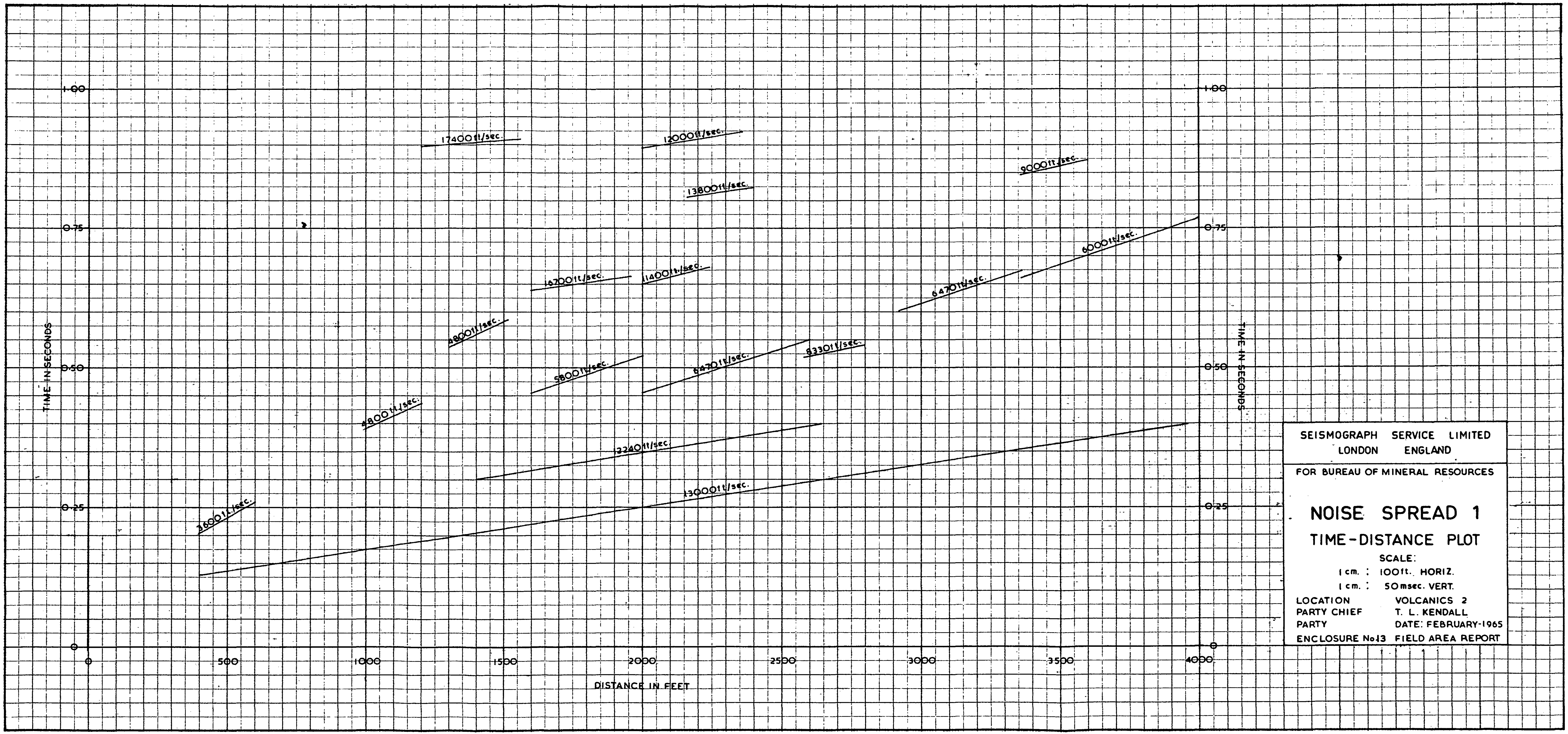
VOLCANICS 2

LINE 171	S.P'S. NOISE SPREAD No. 1		
VELOCITY DISTRIBUTION	—		
WEATHERING VELOCITY (Vw)	—		
HORIZONTAL VELOCITY (Vh)	—		
ELEVATION VELOCITY (Ve)	—		
WEATHERING METHOD	—		
DATUM	—	GEOPHONE INT.	20'
HORIZONTAL SCALE	—		
OFFSET DISTANCE	420' - 3980'		
PLAYBACK FILTER	OUT		
MIXING	—	No. OF SWEEPS	1·10
No. OF VIBRATORS	1		
SWEEP FREQUENCY	10 – 113		
TYPE OF PROFILING	IN LINE		

VIBRATOR PATTERN:
ZERO

GEOPHONE PATTERN
10 GEOPHONES AT RIGHT ANGLES TO LINE

PARTY	243	DATE FEBRUARY 1965
ENCLOSURE	No. 12	FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

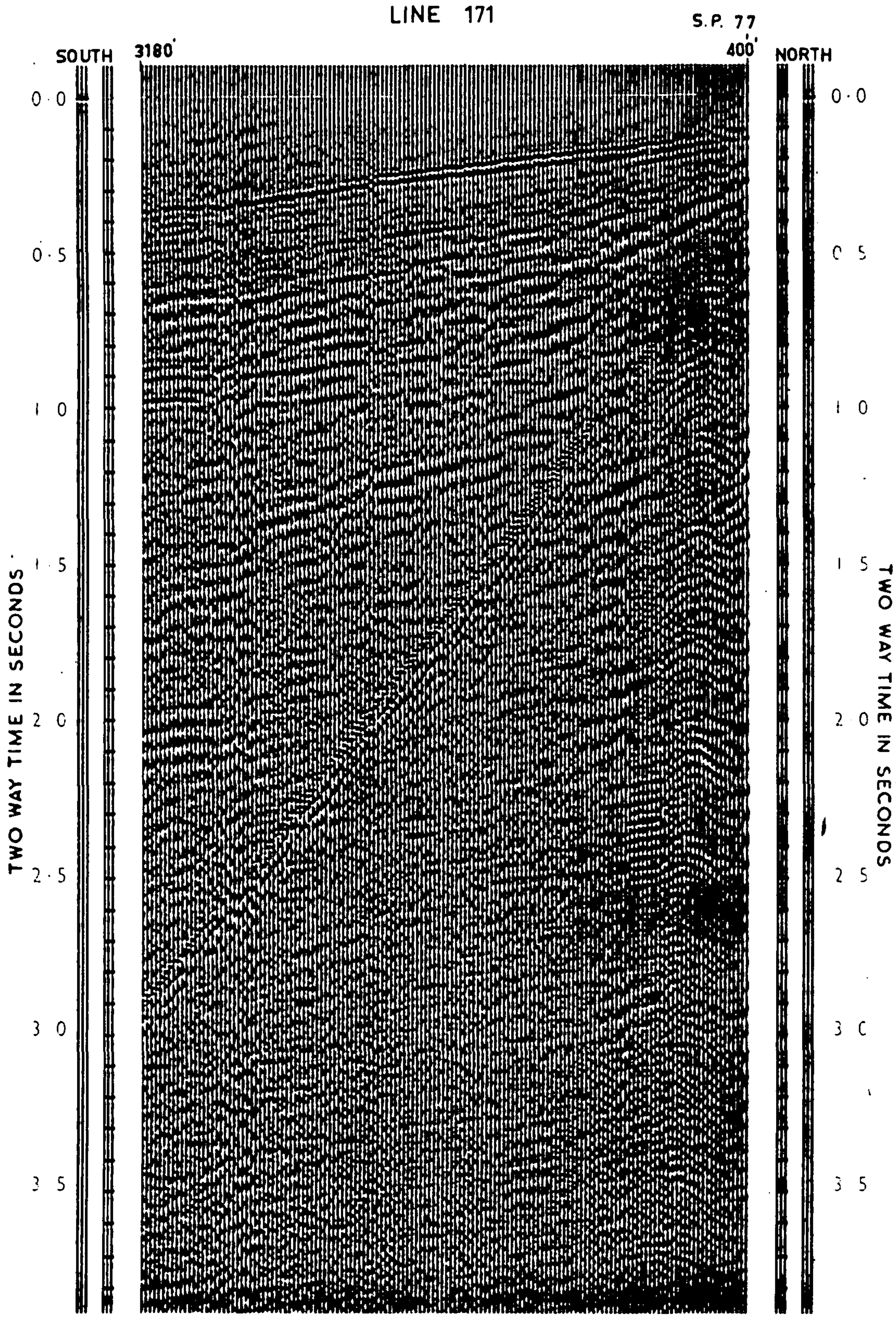
NOISE SPREAD 1

TIME-DISTANCE PLOT

SCALE:
1 cm. : 100 ft. HORIZ.
1 cm. : 50 msec. VERT.

LOCATION	VOLCANICS 2
PARTY CHIEF	T. L. KENDALL
PARTY	DATE: FEBRUARY-1965
ENCLOSURE No.13	FIELD AREA REPORT


RESPONSE - H (db)
FREQUENCY (cps)
WAVE NUMBER - K
LEGEND:
V_A = 13300 ft./sec.
V_A = 6470 ft./sec.
V_A = 12240 ft./sec.
V_A = 4800 ft./sec.
V_A = 5800 ft./sec.
V_A = 12000 ft./sec.
V_A = 13800 ft./sec.
V_A = 6000 ft./sec.
V_A = 8330 ft./sec.
V_A = 9000 ft./sec.
V_A = 17400 ft./sec.
V_A = 5600 ft./sec.
V_A = 11400 ft./sec.
V_A = 16700 ft./sec.
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
NOISE SPREAD 1.
RESPONSE-WAVE No. PLOT
FREQUENCY-WAVE No. PLOT
RESPONSE-FREQUENCY PLOT
LOCATION VOLCANICS 2
PARTY CHIEF T. L. KENDALL
PARTY 243 FEBRUARY 1965
ENCLOSURE No. 14 FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
FOR BUREAU OF MINERAL RESOURCES

NOISE SPREAD

LINE 171 S.P'S. — No.2

VELOCITY DISTRIBUTION	—		
WEATHERING VELOCITY (Vw)	—		
HORIZONTAL VELOCITY (Vh)	—		
ELEVATION VELOCITY (Ve)	—		
WEATHERING METHOD	—		
DATUM	—	GEOPHONE INT.	20
HORIZONTAL SCALE	—		
OFFSET DISTANCE	400 — 3180		
PLAYBACK FILTER	OUT		
MIXING	—	No. OF SWEEPS	1 - 10
No OF VIBRATORS	1		
SWEEP FREQUENCY	10 - 113		
TYPE OF PROFILING	IN LINE		

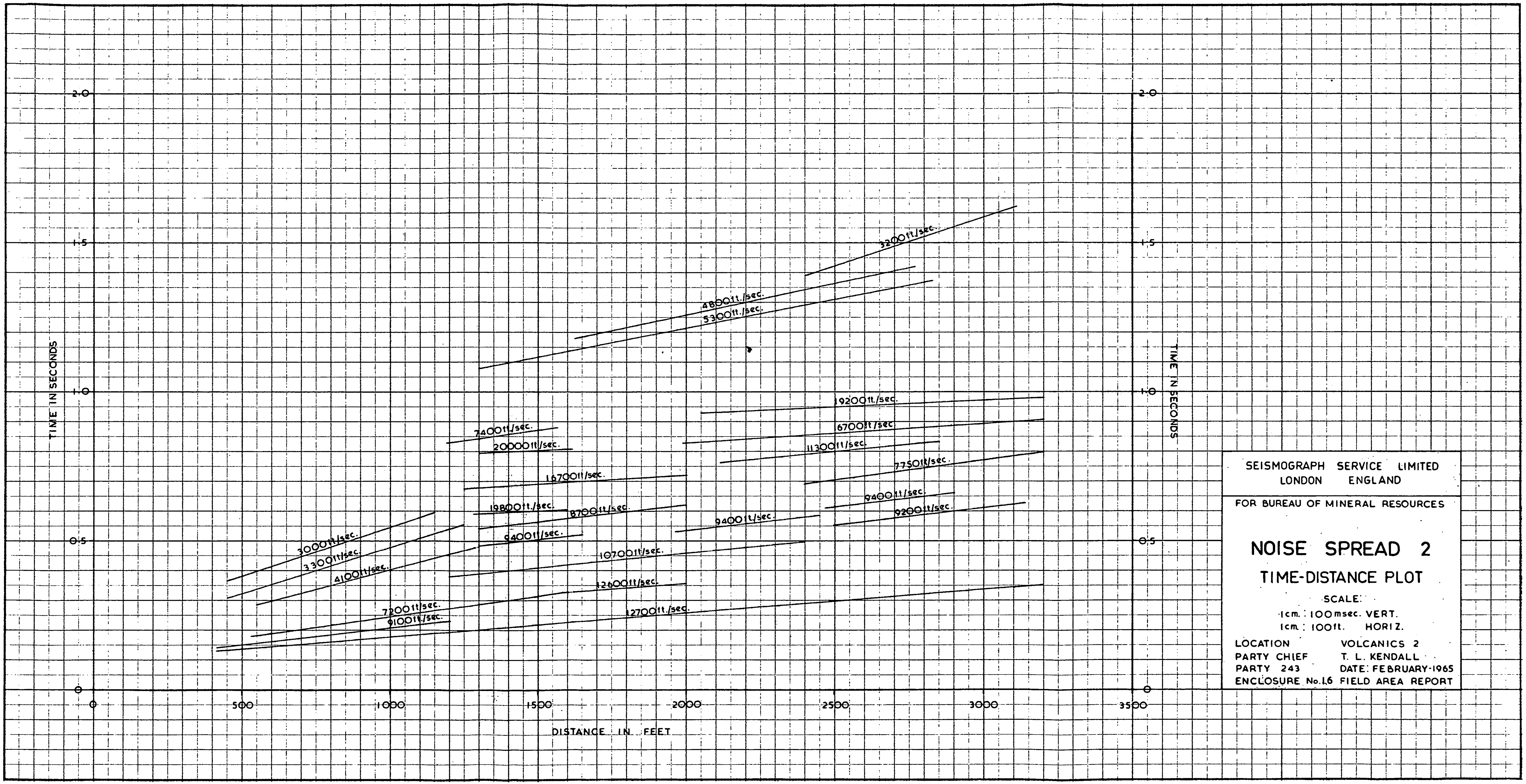
VIBRATOR PATTERN:

ZERO

GEOPHONE PATTERN:

10 GEOPHONES AT RIGHT ANGLES TO LINE

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No.15	FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

NOISE SPREAD 2

TIME-DISTANCE PLOT

SCALE:
1cm. : 100msec. VERT.
1cm. : 100ft. HORIZ.

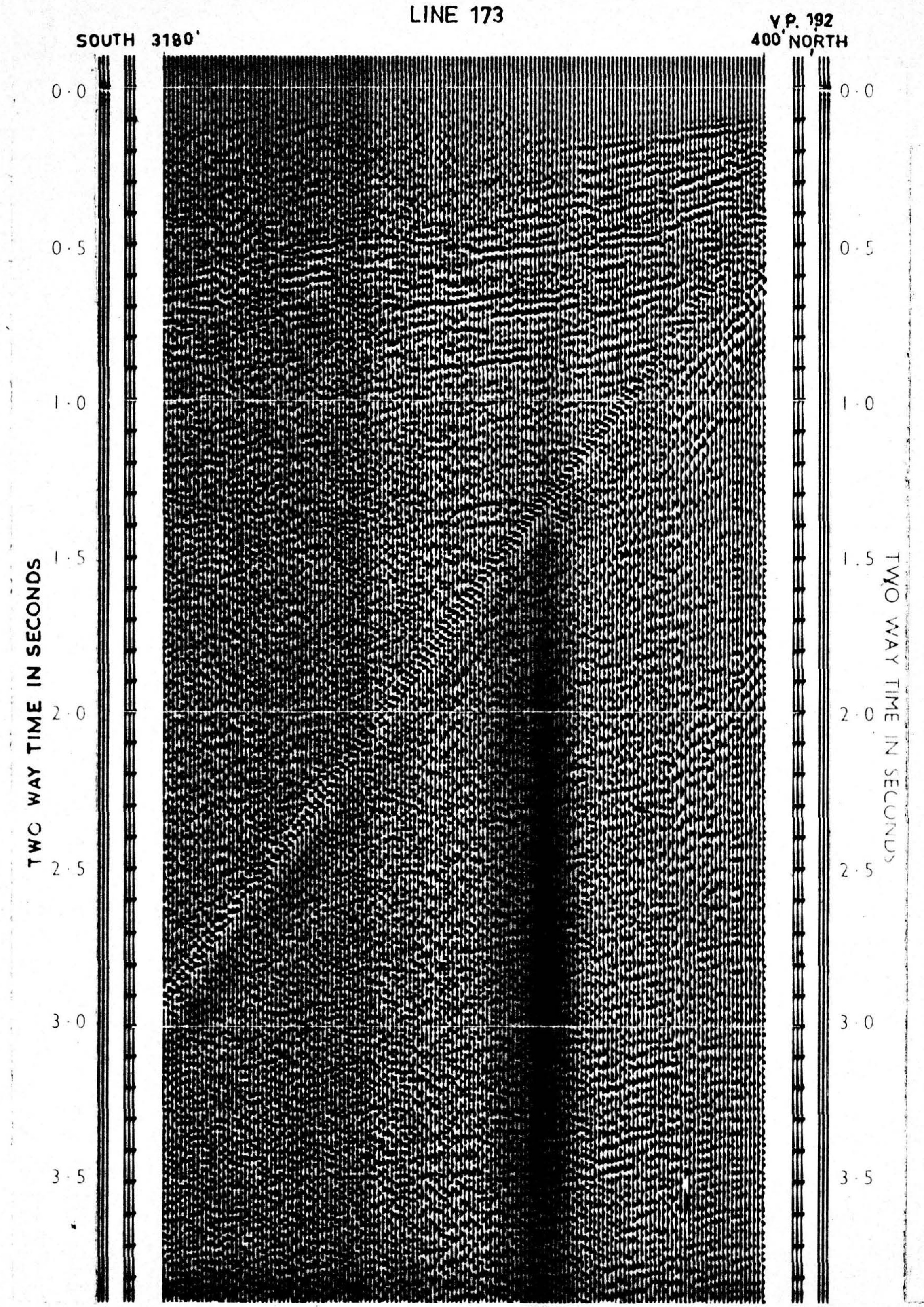
LOCATION	VOLCANICS 2
PARTY CHIEF	T. L. KENDALL
PARTY 243	DATE: FEBRUARY-1965
ENCLOSURE No.16	FIELD AREA REPORT

SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

NOISE SPREAD 2.
RESPONSE-WAVE No. PLOT
FREQUENCY-WAVE No. PLOT
RESPONSE-FREQUENCY PLOT

LOCATION VOLCANICS 2
PARTY 243 LINE 171
PARTY CHIEF T.L.KENDALL
ENCLOSURE No.17 FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

VOLCANICS 3

LINE 173 S.P.'S. NOISE SPREAD No. 4

VELOCITY DISTRIBUTION	—
WEATHERING VELOCITY (V_w)	—
HORIZONTAL VELOCITY (V_h)	—
ELEVATION VELOCITY (V_e)	—
WEATHERING METHOD	—
HORIZONTAL SCALE	DATUM
TYPE OF PROFILING	IN LINE
GEOPHONE INTERVAL	20'
OFFSET DISTANCE	400' – 3180'
No. AND TYPE OF VIBRATORS	1
SWEEP FREQUENCY 10 – 113	No. OF SWEEPS
PLAYBACK FILTER	—
MIXING	—
VIBRATOR PATTERN: NIL	

No. OF SWEEPS:

INCREASES FROM 1 SPT FOR # 1 TO 7 SPT ON #140

GEOPHONE PATTERN:

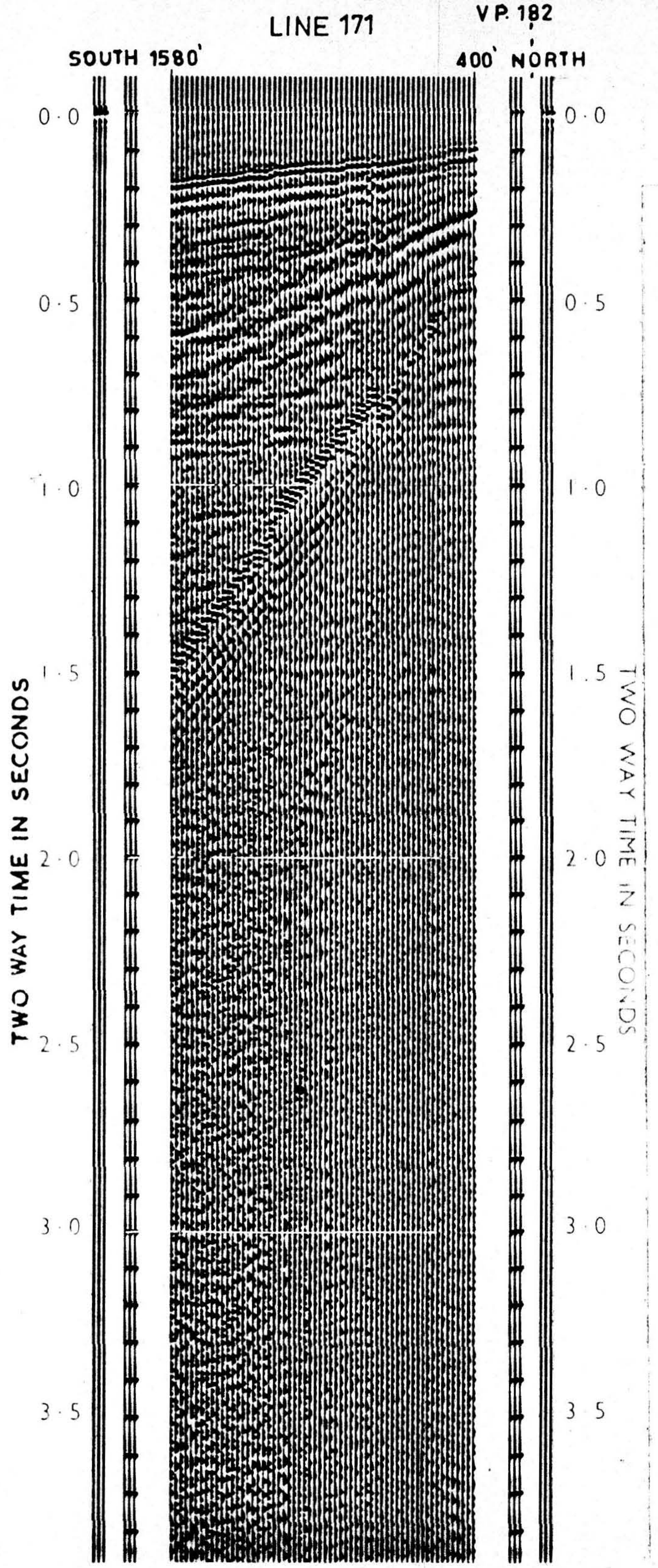
10 GEOPHONES

10' IN LINE AT RIGHT ANGLES TO

DIRECTION OF SHOOTING

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 19	FIELD AREA REPORT

® A TRADE MARK CONTINENTAL OIL CO.



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

VOLCANICS 2

LINE 171 S.P.'S. NOISE SPREAD No. 3

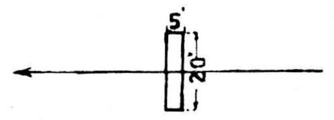
VELOCITY DISTRIBUTION	—
WEATHERING VELOCITY (V_w)	—
HORIZONTAL VELOCITY (V_h)	—
ELEVATION VELOCITY (V_e)	—
WEATHERING METHOD	—
HORIZONTAL SCALE	DATUM
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	20'
OFFSET DISTANCE	400' — 1580'
No. AND TYPE OF VIBRATORS	1
SWEEP FREQUENCY 10 - 113	No. OF SWEEPS
PLAYBACK FILTER	—
MIXING	—
VIBRATOR PATTERN: NIL.	

No. OF SWEEPS:

INCREASES FROM 1 SPT. FOR #1 TO 6 SPT. FOR # 60

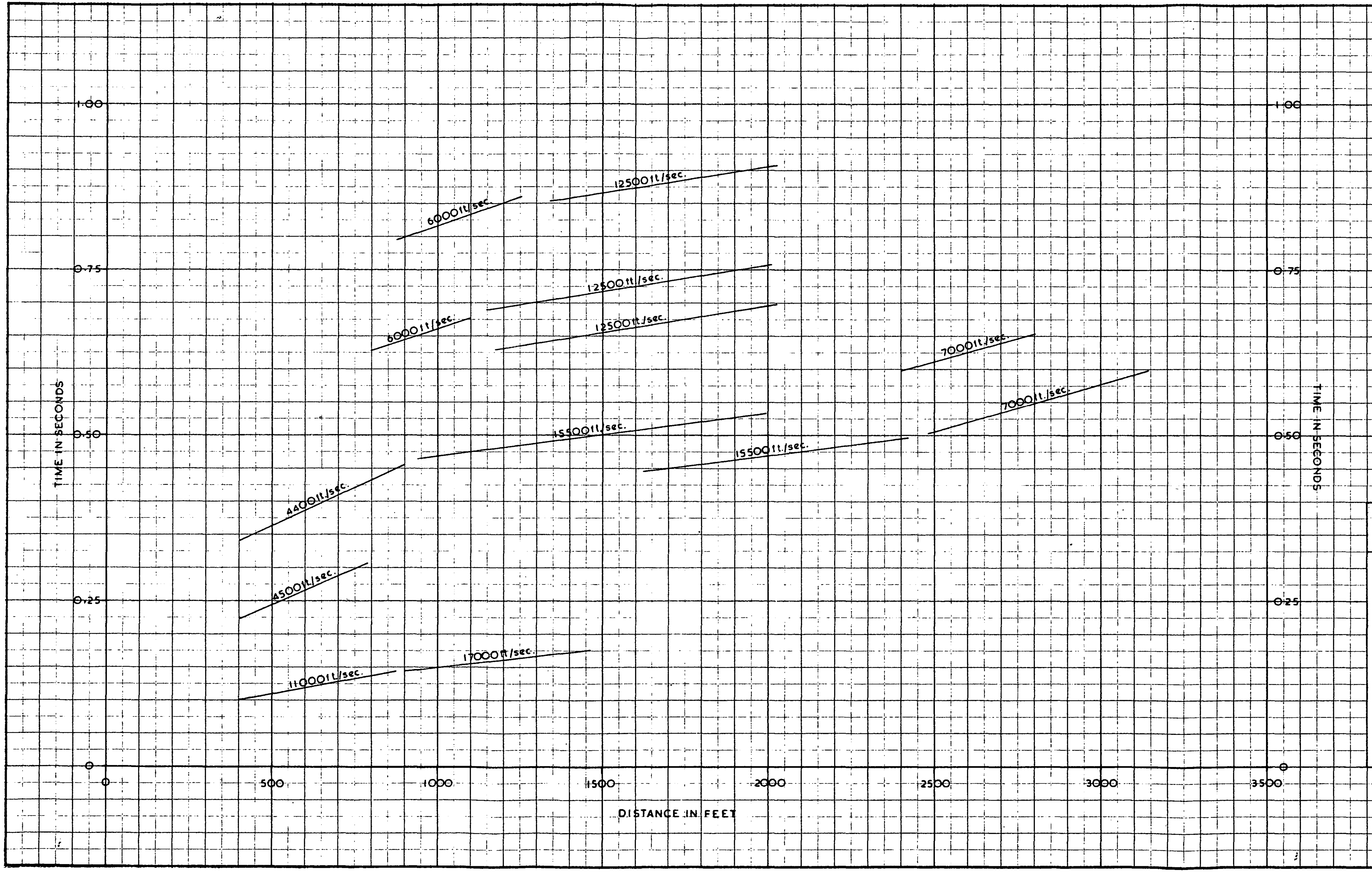
GEOPHONE PATTERN:

5' + 20' RECTANGLE OF 50 GEOPHONES



PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 18	FIELD AREA REPORT

® A TRADE MARK CONTINENTAL OIL CO.



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

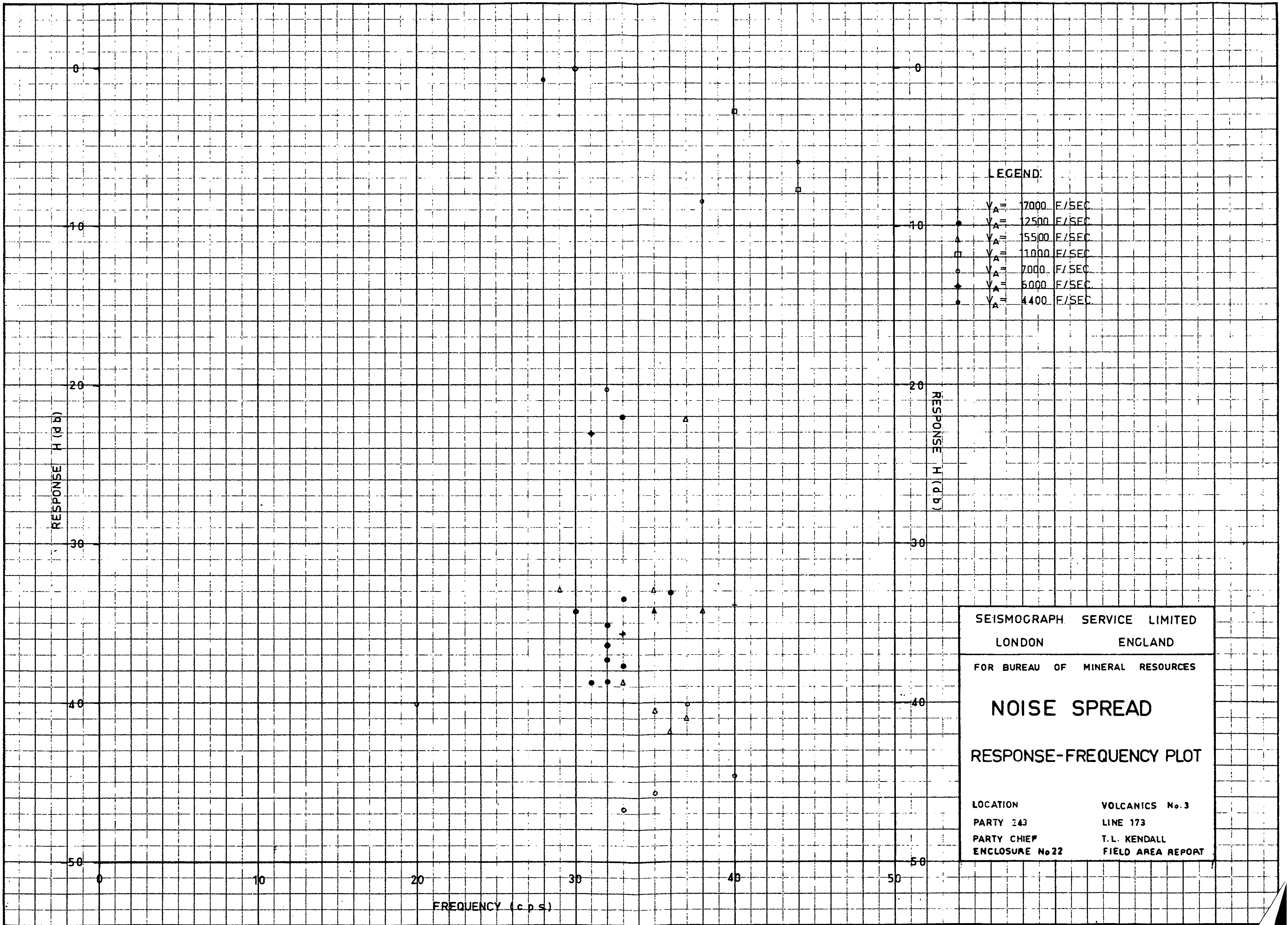
NOISE SPREAD

TIME-DISTANCE PLOT

SCALE:
1cm: 100 ft HORIZ.
1cm: 50 msec. VERT.

LOCATION	VOLCANICS 3
PARTY CHIEF	T. L. KENDALL
PARTY	DATE: FEBRUARY-1965
ENCLOSURE No. 20	FIELD AREA REPORT

RESPONSE H (d b.)
WAVE NUMBER K
RESPONSE H (d b.)
FREQUENCY (c p s.)
WAVE NUMBER K
FREQUENCY (c p s.)
LEGEND:
V_A = 17000 F/SEC.
V_A = 12000 F/SEC.
V_A = 15500 F/SEC.
V_A = 11000 F/SEC.
V_A = 7000 F/SEC.
V_A = 6000 F/SEC.
V_A = 4400 F/SEC.
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
NOISE SPREAD
RESPONSE - WAVE No. PLOT
FREQUENCY - WAVE No. PLOT
LOCATION VOLCANICS No 3
PARTY 243 LINE 173
PARTY CHIEF T.L. KENDALL
ENCLOSURE No.21 FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

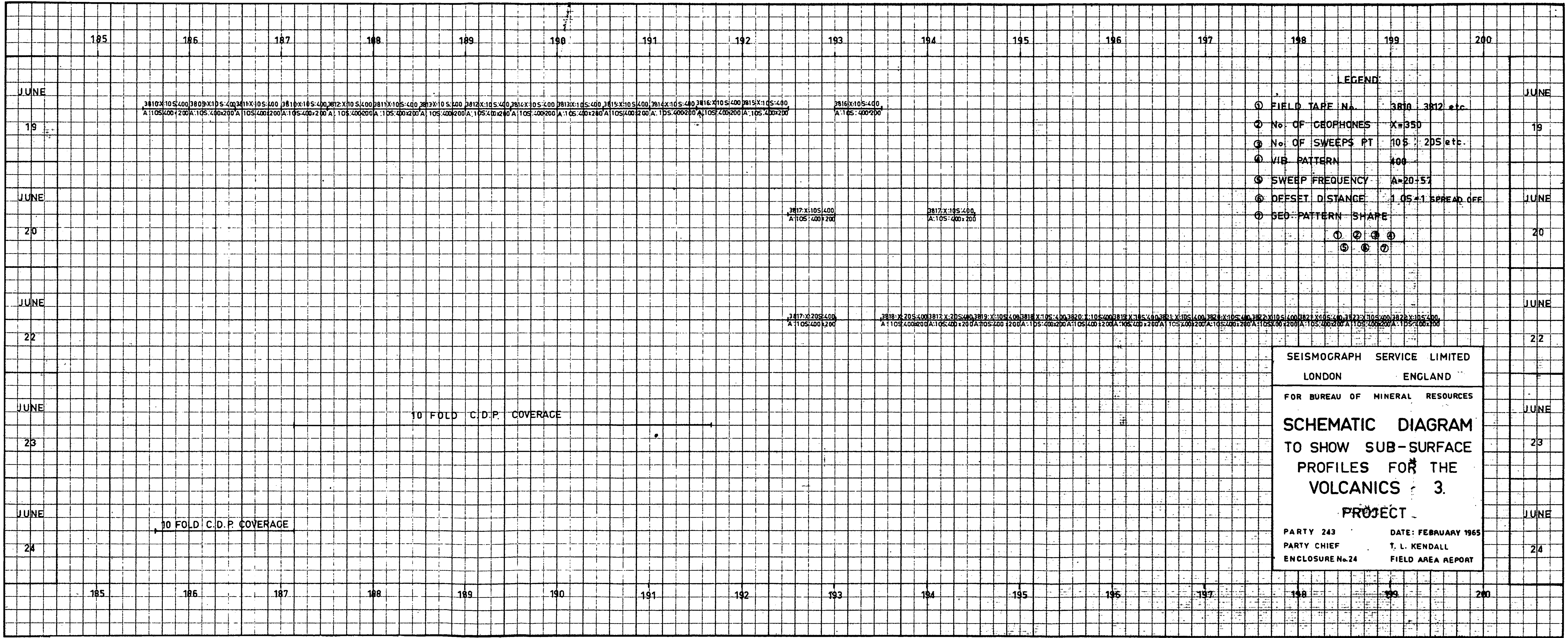
FOR BUREAU OF MINERAL RESOURCES

NOISE SPREAD

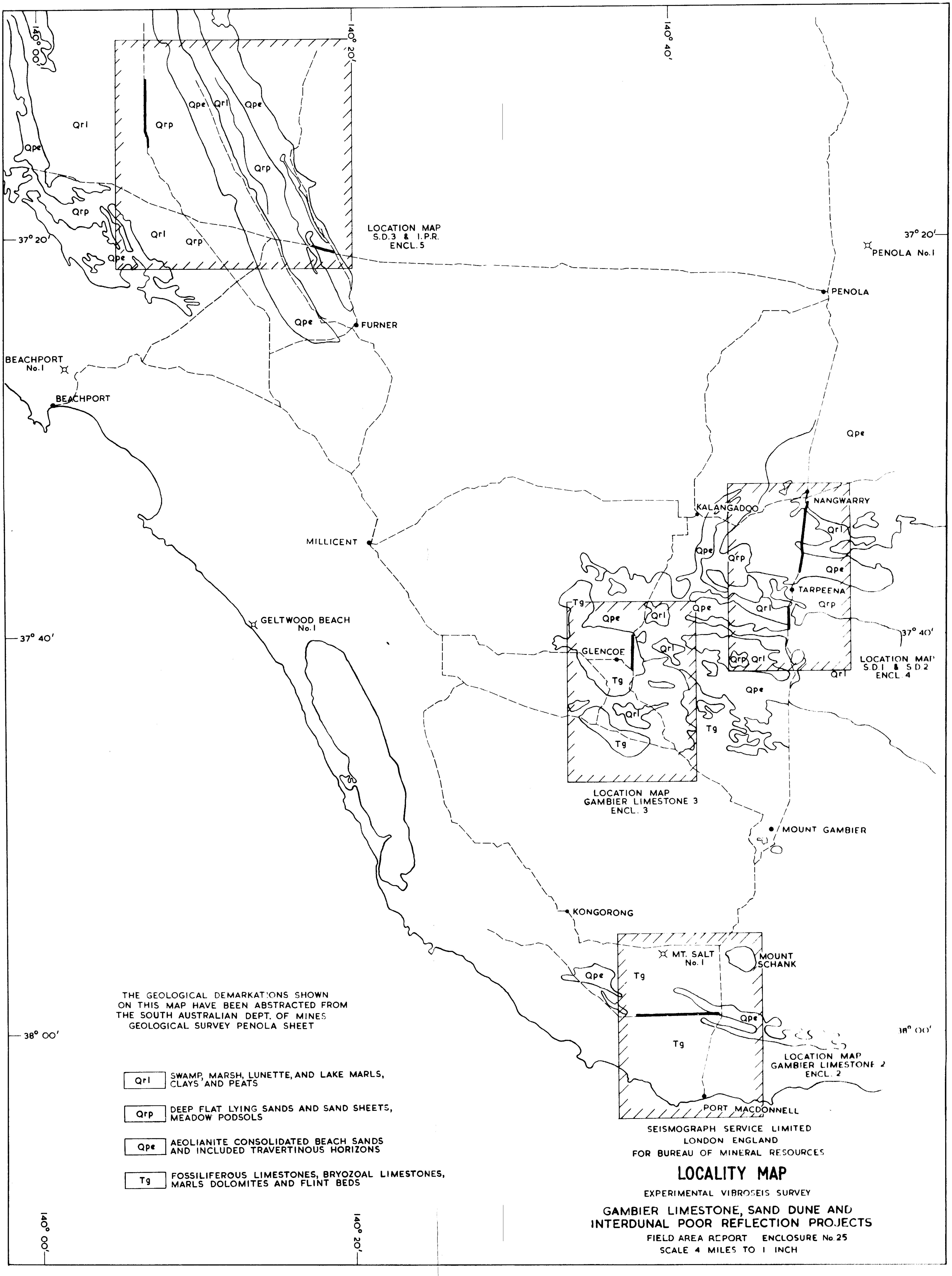
RESPONSE-FREQUENCY PLOT

LOCATION	VOLCANICS No. 3
PARTY 343	LINE 173
PARTY CHIEF	T.L. KENDALL
ENCLOSURE No 22	FIELD AREA REPORT


SOUTH
NORTH
10 FOLD C.D.P COVERAGE
3378 - 3415
10 FOLD C.D.P.
LEGEND:
① FIELD TAPE No. 4176 etc.
② No. OF GEOPHONES A = 350 B = 420 C = 600 D = 800 E = 400 F = 200 G = 40 H = 80
③ No. OF SWEEPS 10S. 20S. etc.
④ VIB. PATTERN 400 ; 600 etc.
⑤ SWEEP FREQUENCY X = 14 - 57 ; Y = 20 - 57 ; Z = 28 - 80 W = 28 - 57 ; Q = 10 - 80 ; V = 20 - 80
⑥ OFFSET DISTANCE 1 0S. 20S. etc.
⑦ GEOPHONE PATTERN SHAPE
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
SCHEMATIC DIAGRAM
TO SHOW SUB-SURFACE
PROFILES FOR THE
VOLCANICS 2
PROJECT
PARTY 243
PARTY CHIEF
ENCLOSURE No.23
DATE FEBRUARY 1965
T.L. KENDALL
FIELD AREA REPORT
G 438-51



185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
JUNE 19
JUNE 20
JUNE 22
JUNE 23
JUNE 24
10 FOLD C.D.P. COVERAGE
10 FOLD C.D.P. COVERAGE
LEGEND
① FIELD TAPE No. 3810 3812 etc.
② No. OF GEOPHONES X=350
③ No. OF SWEEPS PT 10S 20S etc.
④ VIB PATTERN 400
⑤ SWEEP FREQUENCY A=20-57
⑥ OFFSET DISTANCE 1.0S=1 SPREAD OFF
⑦ GEO PATTERN SHAPE
① ② ③ ④
⑤ ⑥ ⑦
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
SCHEMATIC DIAGRAM
TO SHOW SUB-SURFACE
PROFILES FOR THE
VOLCANICS - 3.
PROJECT
PARTY 243
DATE: FEBRUARY 1965
PARTY CHIEF
T. L. KENDALL
ENCLOSURE No. 24
FIELD AREA REPORT



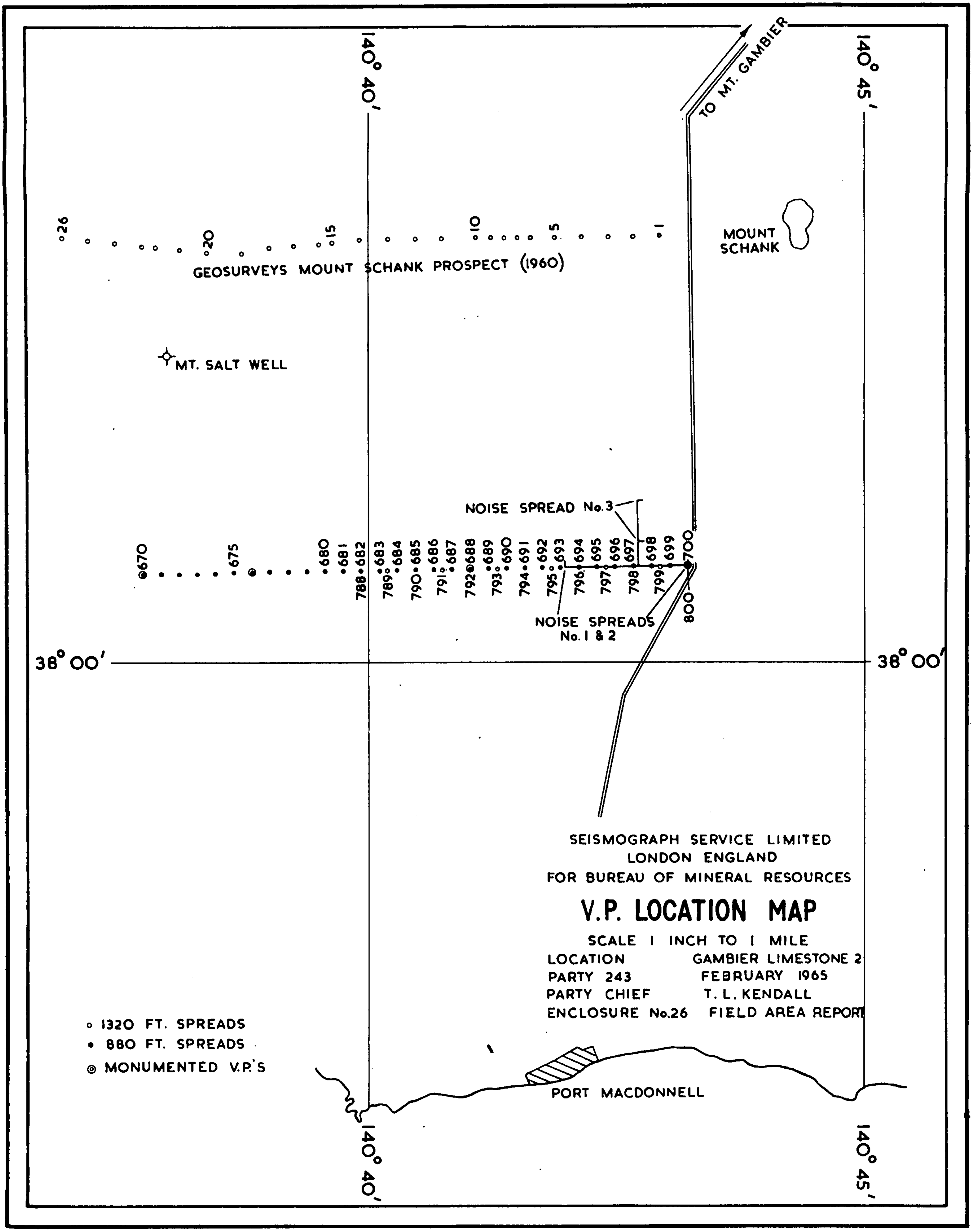
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES

LOCALITY MAP

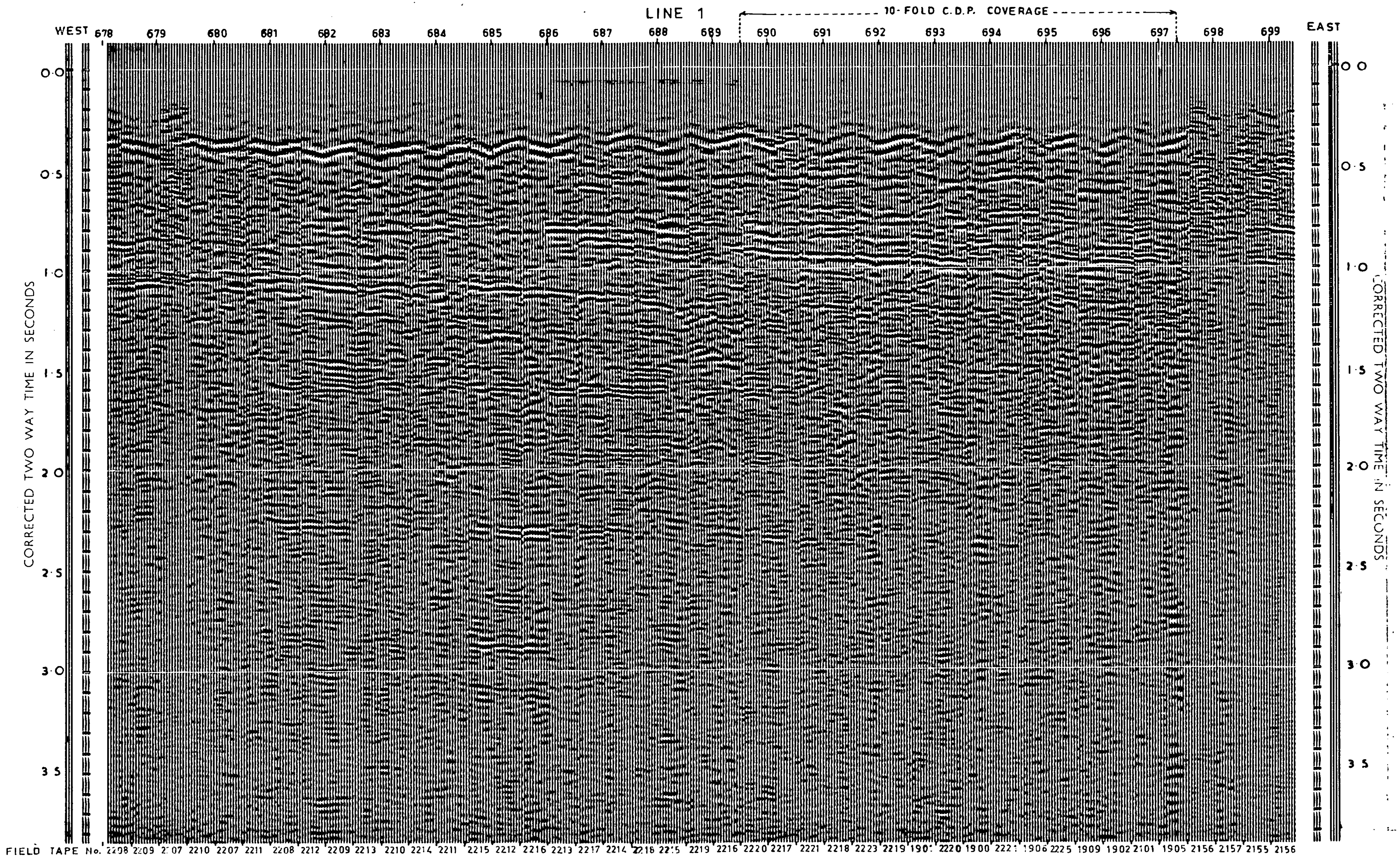
EXPERIMENTAL VIBROSEIS SURVEY

GAMBIER LIMESTONE, SAND DUNE AND
INTERDUNAL POOR REFLECTION PROJECTS

FIELD AREA REPORT ENCLOSURE No. 25
SCALE 4 MILES TO 1 INCH



140° 40′
140° 45′
TO MT. GAMBIER
MOUNT SCHANK
GEOSURVEYS MOUNT SCHANK PROSPECT (1960)
26
20
15
10
5
1
MT. SALT WELL
NOISE SPREAD No. 3
670
675
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
788
789
790
791
792
793
794
795
796
797
798
799
800
NOISE SPREADS No. 1 & 2
38° 00′
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
V.P. LOCATION MAP
SCALE 1 INCH TO 1 MILE
LOCATION GAMBIER LIMESTONE 2
PARTY 243 FEBRUARY 1965
PARTY CHIEF T. L. KENDALL
ENCLOSURE No. 26 FIELD AREA REPORT
1320 FT. SPREADS
880 FT. SPREADS
MONUMENTED V.P.'S
PORT MACDONNELL



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

GAMBIER LIMESTONE 2

LINE 1	S.P'S. 578 - 699
VELOCITY DISTRIBUTION	GELTWOOD BEACH
WEATHERING VELOCITY (V_w)	–
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	7000 F/SEC
WEATHERING METHOD	–
HORIZONTAL SCALE 1" : 1600'	DATUM M.S.L.
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	88'
OFFSET DISTANCE	2684' – 3476'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14 - 57	No. OF SWEEPS
PLAYBACK FILTER	14 - 60
MIXING	3/2 COMPOSITED

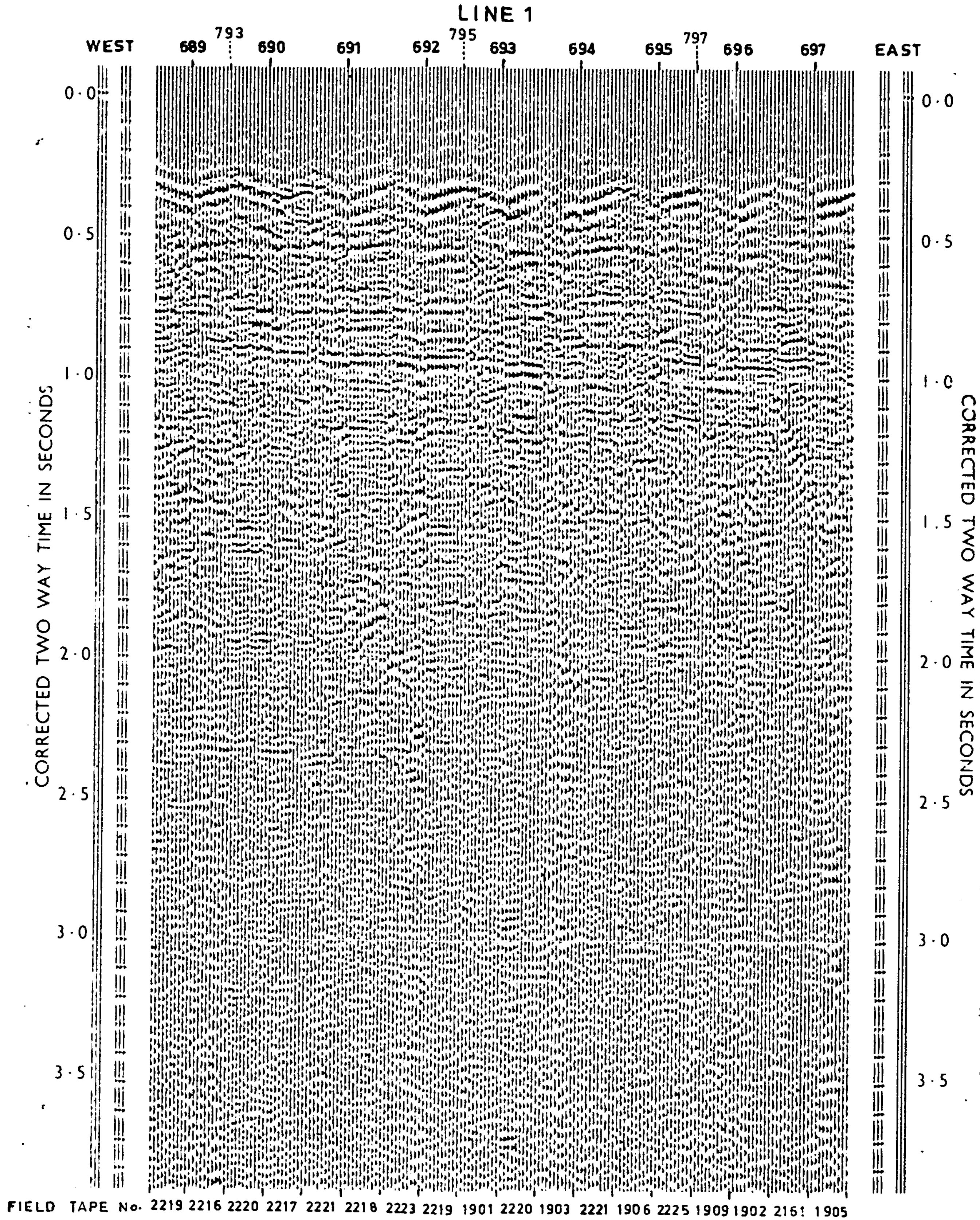
VIBRATOR PATTERN:

SEE SCHEMATIC DIAGRAM

GEOPHONE PATTERN:

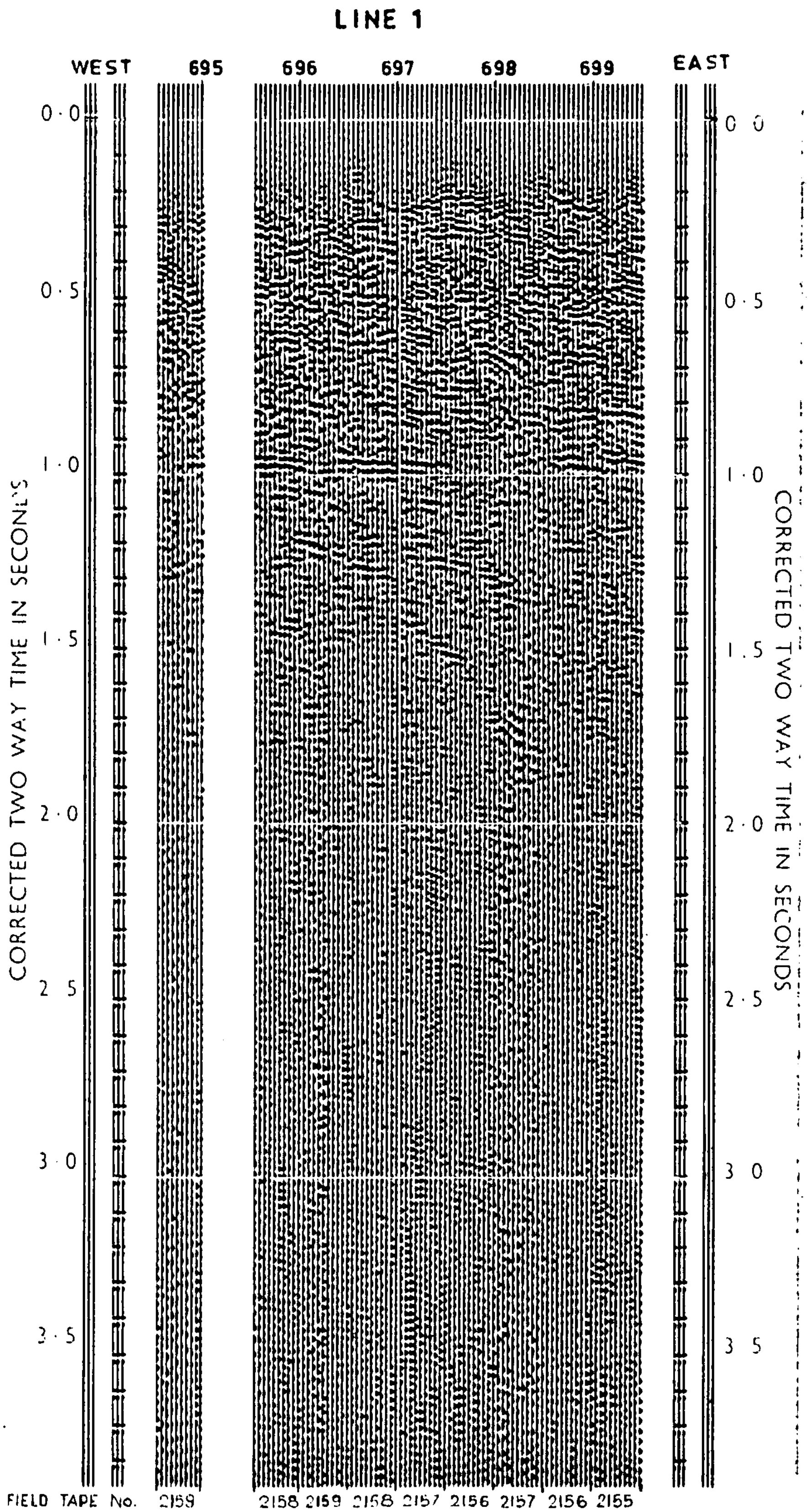
SEE SCHEMATIC DIAGRAM

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No 27	FIELD AREA REPORT



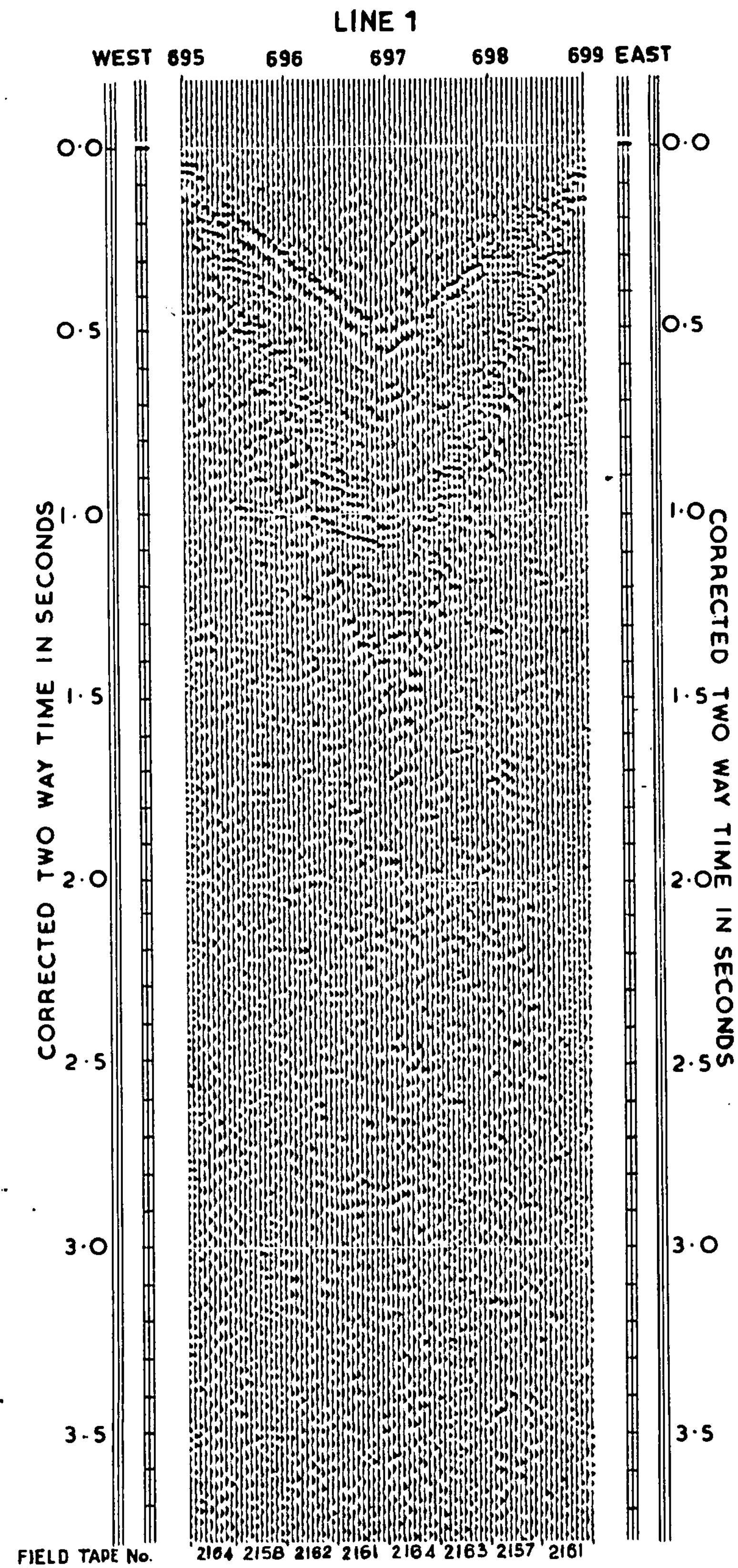
SEISMOGRAPH SERVICE LIMITED LONDON ENGLAND	
VARIABLE AREA CROSS-SECTION VIBROSEIS* FOR BUREAU OF MINERAL RESOURCES **GAMBIER LIMESTONE 2**	
LINE 1 S.P.S. 689 — 697	
VELOCITY DISTRIBUTION	GELTWOOD BEACH
WEATHERING VELOCITY (V_w)	—
HORIZONTAL VELOCITY (V_h)	—
ELEVATION VELOCITY (V_e)	7000 F/SEC.
WEATHERING METHOD	—
HORIZONTAL SCALE 1": 1600'	DATUM MSL
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	88'
OFFSET DISTANCE	2684' - 3476'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14-57	No. OF SWEEPS 20
PLAYBACK FILTER	14 — 60
MIXING	—
VIBRATOR PATTERN: SEE SCHEMATIC DIAGRAM	
GEOPHONE PATTERN: — 400' X 400' DIAMOND OF 400 GEOPHONES	
PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 28	FIELD AREA REPORT

*A TRADE MARK CONTINENTAL OIL CO.



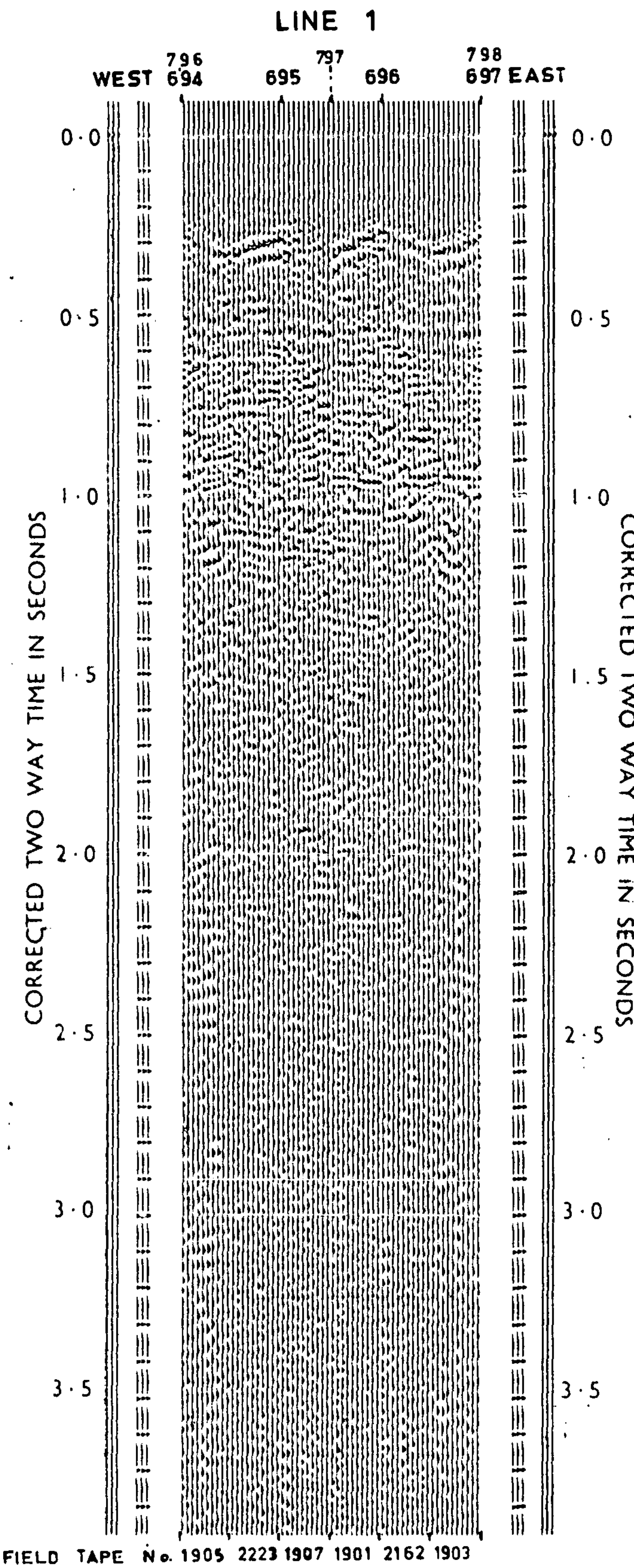
SEISMOGRAPH SERVICE LIMITED LONDON ENGLAND	
VARIABLE AREA CROSS-SECTION VIBROSEIS* FOR BUREAU OF MINERAL RESOURCES	
GAMBIER LIMESTONE 2	
LINE 1	S.P.'S. 695–699
VELOCITY DISTRIBUTION	BEACHPORT No.1
WEATHERING VELOCITY (V_w)	–
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	7000 FT. SEC.
WEATHERING METHOD	–
HORIZONTAL SCALE 1: 1600'	DATUM M.S.L
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	88'
OFFSET DISTANCE	924' – 1716'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14–57	No. OF SWEEPS 10-20
PLAYBACK FILTER	40 – 60
MIXING	–
VIBRATOR PATTERN: 264' IN LINE	
GEOPHONE PATTERN: 264' X 240' RECTANGLE OF 350 GEOPHONES	
PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 29	FIELD AREA REPORT

*A TRADE MARK CONTINENTAL OIL CO.



SEISMOGRAPH SERVICE LIMITED LONDON ENGLAND	
VARIABLE AREA CROSS-SECTION VIBROSEIS* FOR BUREAU OF MINERAL RESOURCES **GAMBIER LIMESTONE 2**	
LINE 1	SP'S. 695 — 699
VELOCITY DISTRIBUTION	
WEATHERING VELOCITY (V_w)	
HORIZONTAL VELOCITY (V_h)	
ELEVATION VELOCITY (V_e)	
WEATHERING METHOD	
HORIZONTAL SCALE 1": 1600'	DATUM M.S.L.
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	88'
OFFSET DISTANCE	0' — 2684' — 0'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14 — 57	No. OF SWEEPS 10
PLAYBACK FILTER	14 — 60
MIXING	—
VIBRATOR PATTERN: 264' IN LINE	
GEOPHONE PATTERN: 264' X 240' RECTANGLE OF 350 GEOPHONES	
PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 30	FIELD AREA REPORT

*A TRADE MARK CONTINENTAL OIL CO.



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LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

GAMBIER LIMESTONE 2

LINE 1 SP'S. 694 – 697

VELOCITY DISTRIBUTION	GELTWOOD BEACH
WEATHERING VELOCITY (V_w)	–
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	7000 F/SEC
WEATHERING METHOD	–
HORIZONTAL SCALE 1 : 1600	DATUM M.S.L.
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	88'
OFFSET DISTANCE	1804' – 2596'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14–57	No. OF SWEEPS 10-20
PLAYBACK FILTER	14 – 60
MIXING	UNMIXED

VIBRATOR PATTERN:

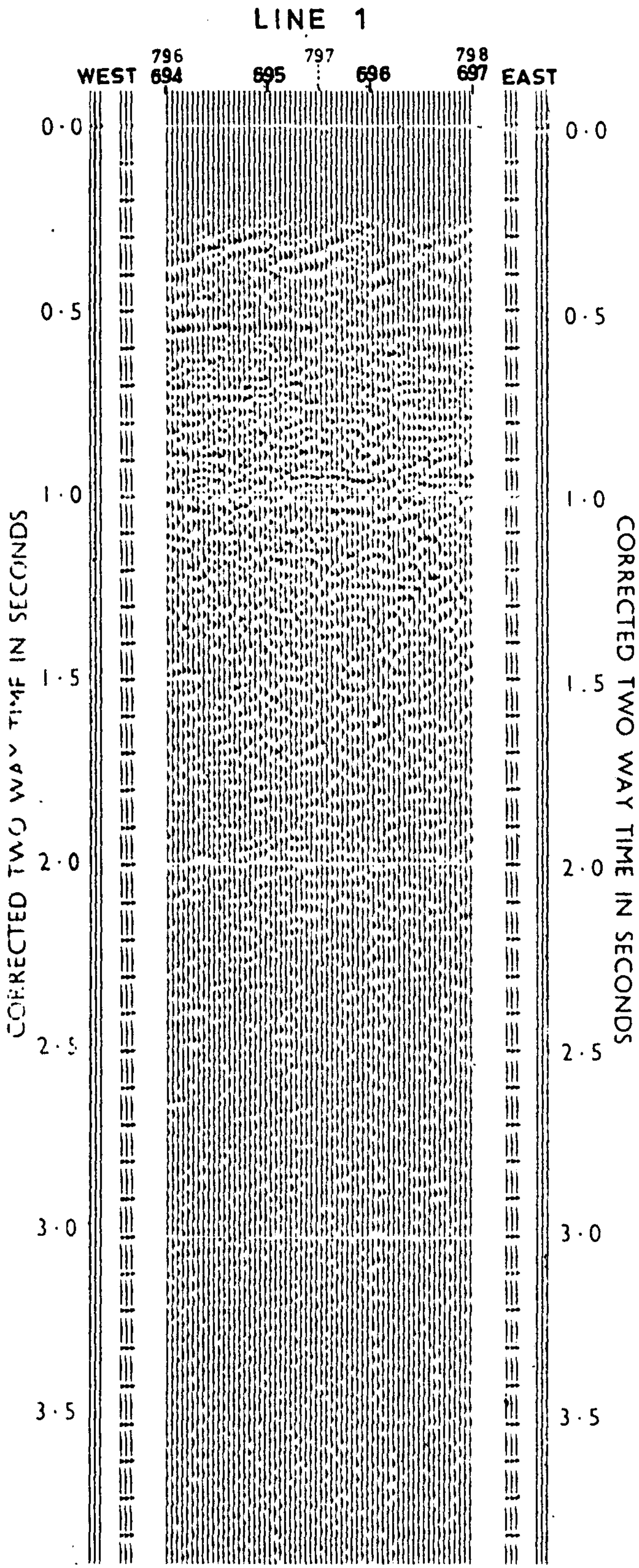
SEE SCHEMATIC DIAGRAM

GEOPHONE PATTERN:

SEE SCHEMATIC DIAGRAM

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 31	FIELD AREA REPORT

®A TRADE MARK CONTINENTAL OIL CO.



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS*
FOR BUREAU OF MINERAL RESOURCES

GAMBIER LIMESTONE 2

LINE 1 S.P.'S. 694 — 697

VELOCITY DISTRIBUTION	CELTWOOD BEACH	
WEATHERING VELOCITY (V_w)	—	
HORIZONTAL VELOCITY (V_h)	—	
ELEVATION VELOCITY (V_e)	7000F/SEC.	
WEATHERING METHOD	—	
HORIZONTAL SCALE 1": 1600'	DATUM M.S.L.	
TYPE OF PROFILING	2-FOLD C.D.P.	
GEOPHONE INTERVAL	88'	
OFFSET DISTANCE	1804'-2596'	2684'-3476'
No. AND TYPE OF VIBRATORS	3	
SWEEP FREQUENCY 14 — 57	No. OF SWEEPS 10-20	
PLAYBACK FILTER	14 — 60	
MIXING	—	

VIBRATOR PATTERN:

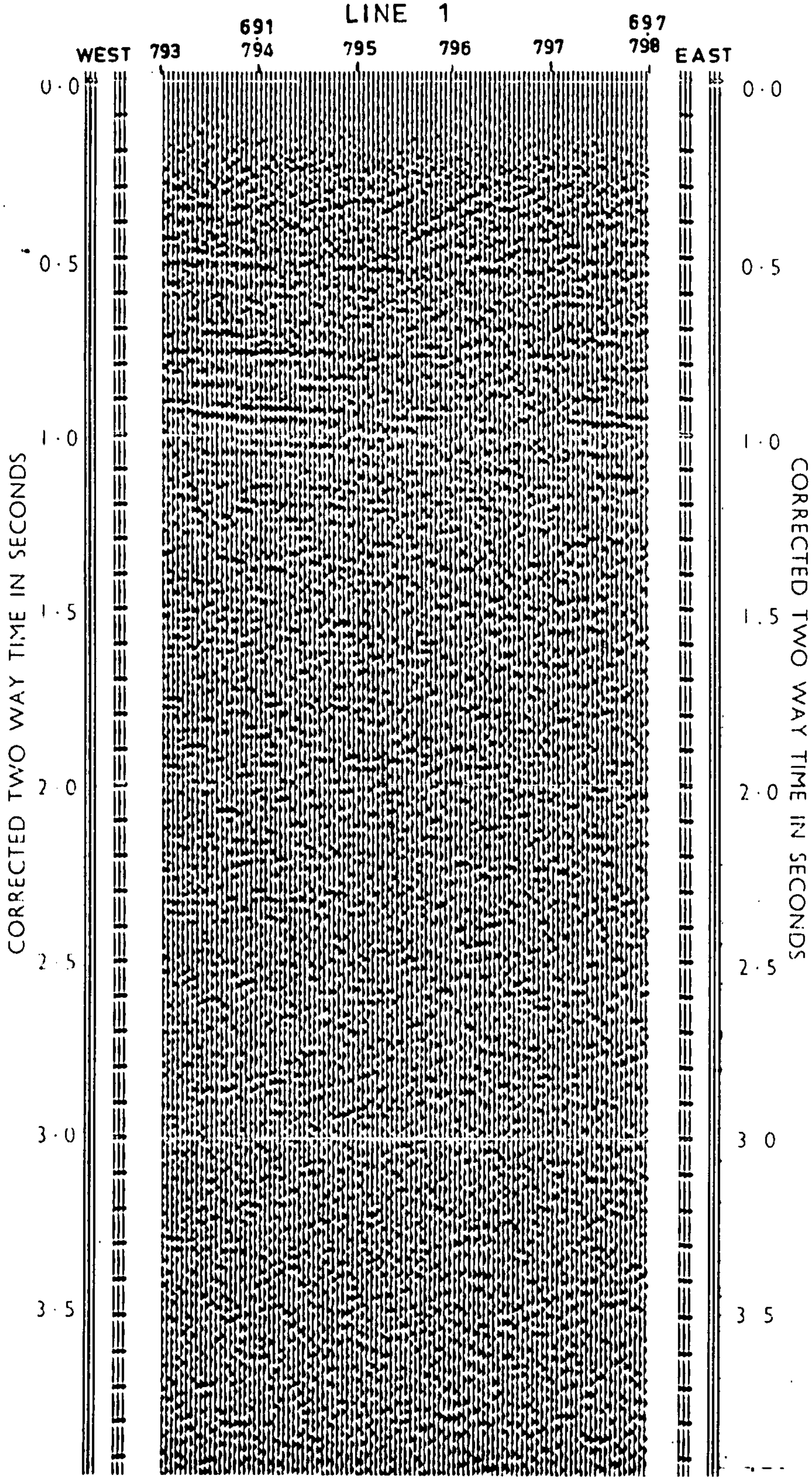
SEE SCHEMATIC DIAGRAM

GEOPHONE PATTERN:

SEE SCHEMATIC DIAGRAM

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 32	FIELD AREA REPORT

*A TRADE MARK CONTINENTAL OIL CO.



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LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

GAMBIER LIMESTONE 2

LINE 1 SP'S. 793 - 798

VELOCITY DISTRIBUTION	BEACHPORT No.1
WEATHERING VELOCITY (V_w)	—
HORIZONTAL VELOCITY (V_h)	—
ELEVATION VELOCITY (V_e)	7000 F/SEC
WEATHERING METHOD	—
HORIZONTAL SCALE 1": 2300'	DATUM M.S.L.
TYPE OF PROFILING	10-FOLD C.D.P.
TRACE INTERVAL	132'
OFFSET DISTANCE	1386' — 3894'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14 - 57	No. OF SWEEPS 10
PLAYBACK FILTER	14 - 60
MIXING	—

VIBRATOR PATTERN:

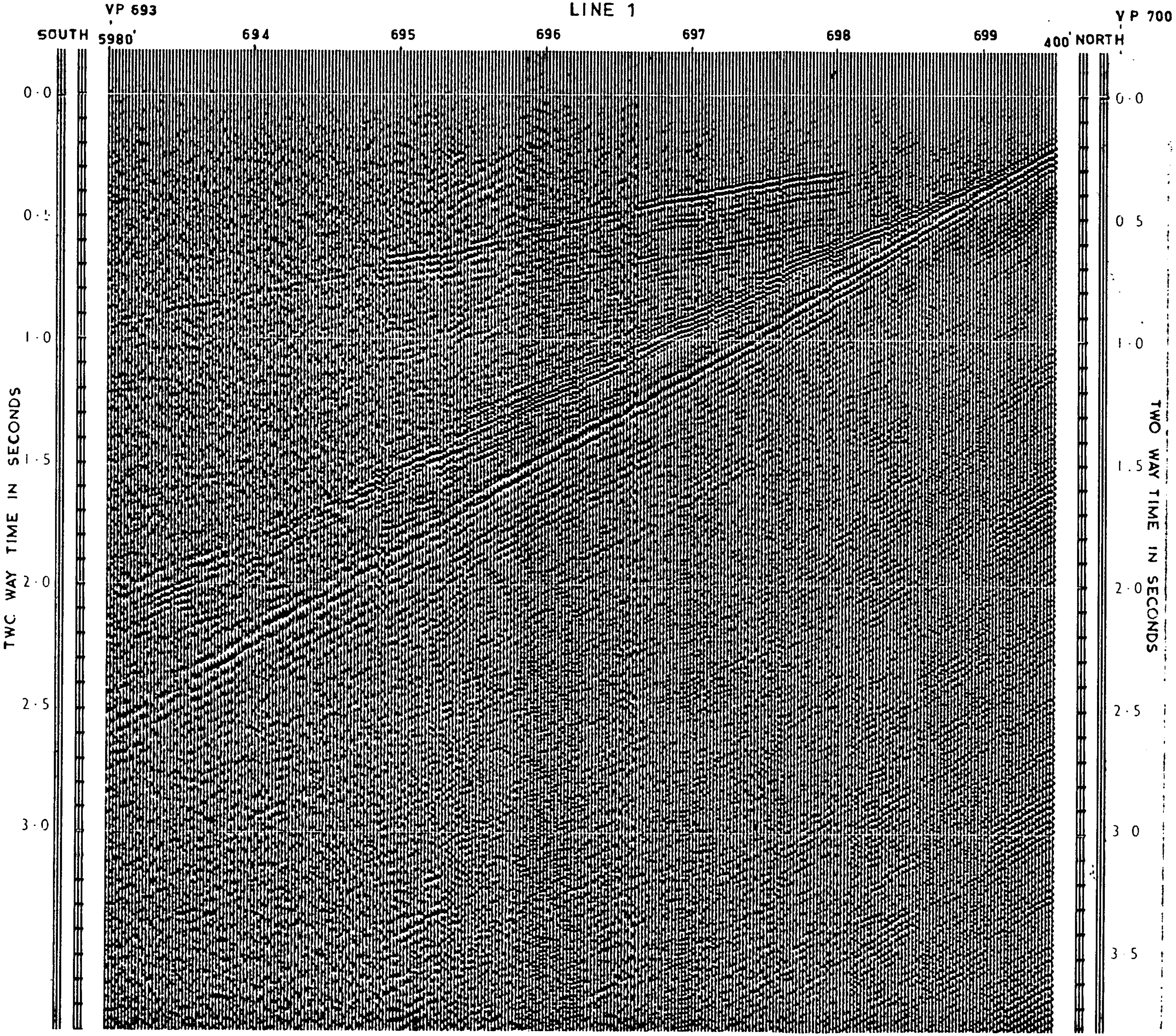
200' IN LINE

GEOPHONE PATTERN:

200' ALONG LINE WITH 40 GEOPHONES PER TRACE

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 33	FIELD AREA REPORT

® A TRADE MARK CONTINENTAL OIL CO



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LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

GAMBIER LIMESTONE 2

LINE 1	S.P.'S. NOISE SPREAD No 5
VELOCITY DISTRIBUTION	—
WEATHERING VELOCITY (V_w)	—
HORIZONTAL VELOCITY (V_h)	—
ELEVATION VELOCITY (V_e)	—
WEATHERING METHOD	—
HORIZONTAL SCALE	DATUM
TYPE OF PROFILING	IN LINE: TRANSPOSED
GEOPHONE INTERVAL	20'
OFFSET DISTANCE	400'–5980'
No. AND TYPE OF VIBRATORS	1
SWEEP FREQUENCY 10–113	No. OF SWEEPS
PLAYBACK FILTER	—
MIXING	—
VIBRATOR PATTERN: NIL.	

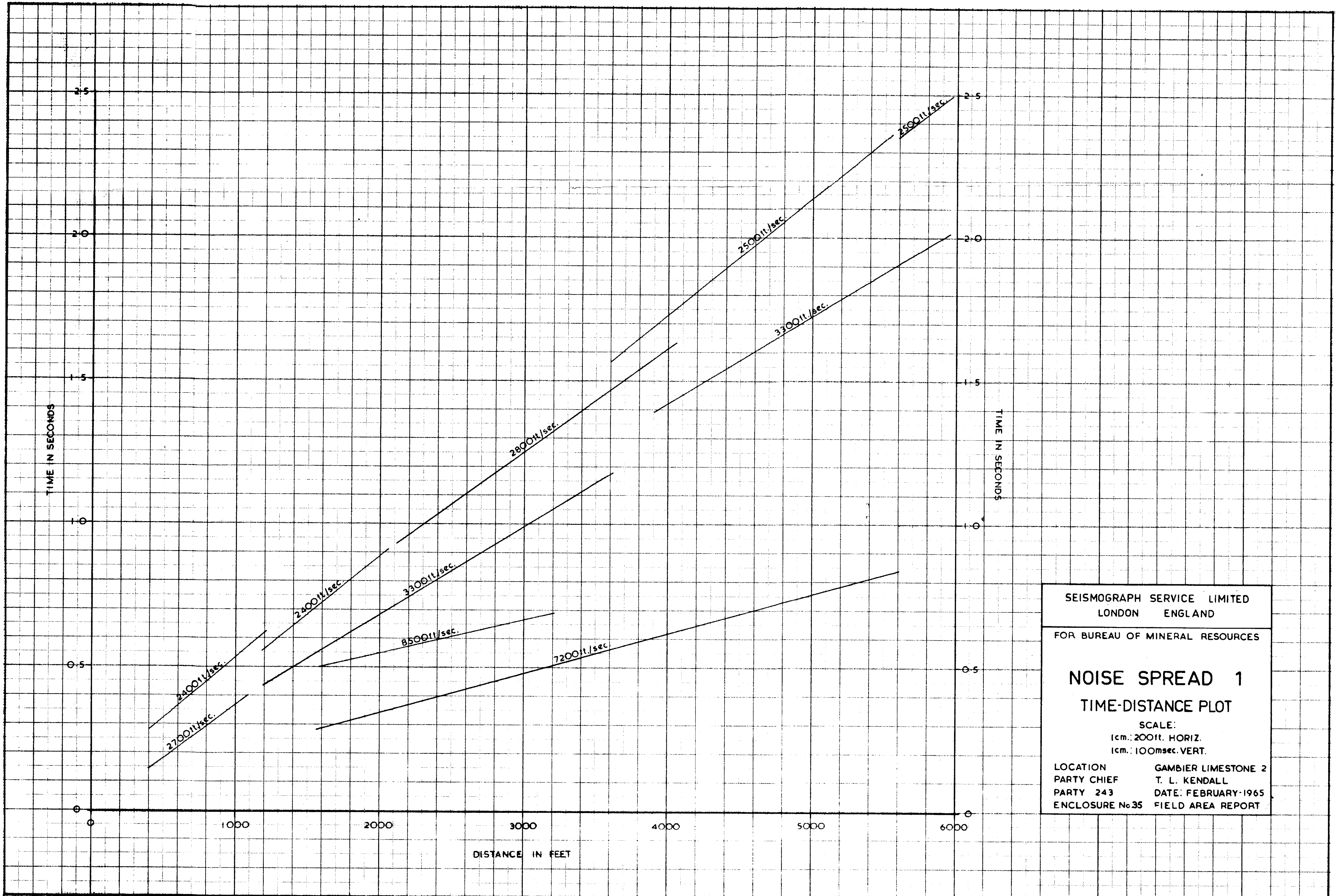
No. OF SWEEPS:
IN LINE
INCREASES FROM 1 S.P.T. FOR 1 TO 10 S.P.T. ON 200
TRANSPOSED: 3 S.P.T.

GEOPHONE PATTERN:
IN LINE: 10' GEOPHONES SPACED
10 IN LINE AT RIGHT ANGLES TO DIRECTION OF SHOOTING

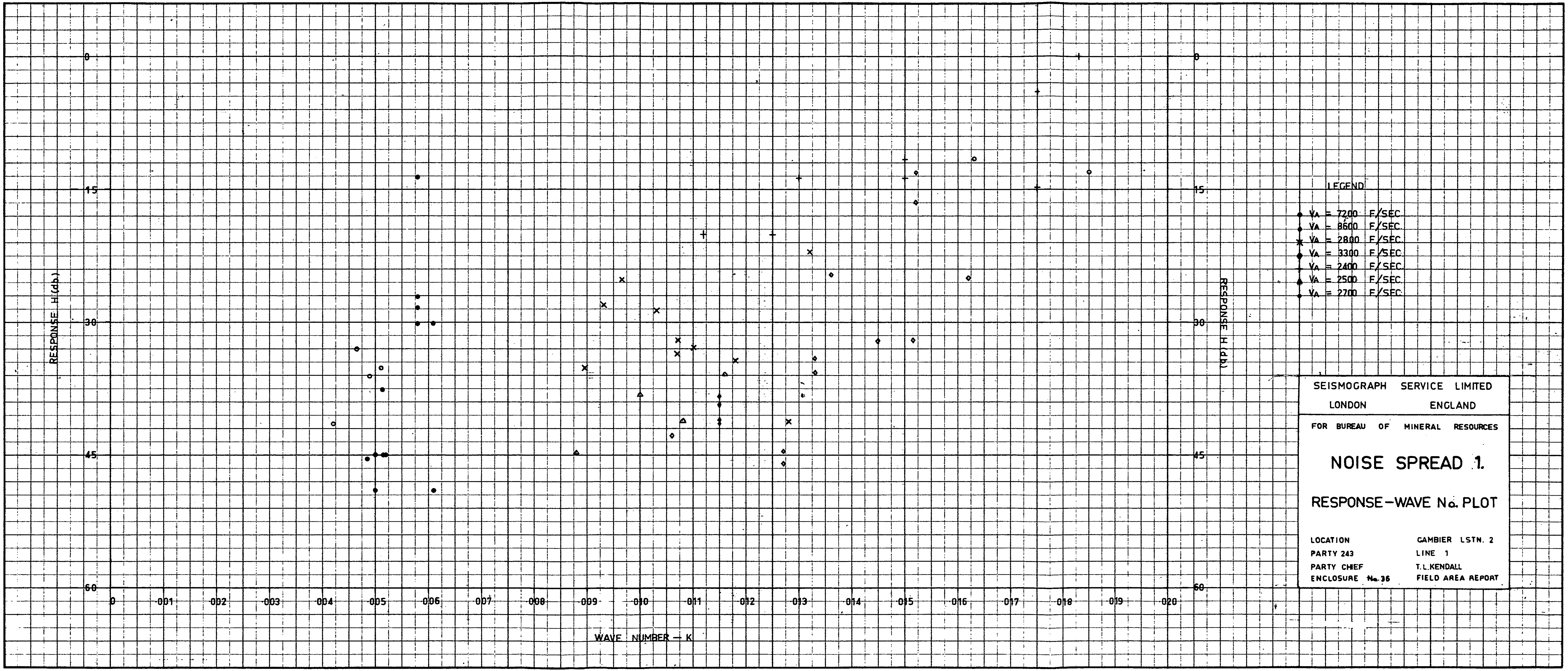
TRANSPOSED 5' x 20' RECTANGLE OF 50 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 34	FIELD AREA REPORT

®A TRADE MARK CONTINENTAL OIL CO.



TIME IN SECONDS
2·5
2·0
1·5
1·0
0·5
0
1000
2000
3000
4000
5000
6000
DISTANCE IN FEET
2500ft./sec.
2500ft./sec.
3300ft./sec.
2800ft./sec.
2400ft./sec.
3300ft./sec.
8500ft./sec.
7200ft./sec.
2400ft./sec.
2700ft./sec.
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
NOISE SPREAD 1
TIME-DISTANCE PLOT
SCALE:
1cm.: 200ft. HORIZ.
1cm.: 100msec. VERT.
LOCATION GAMBIER LIMESTONE 2
PARTY CHIEF T. L. KENDALL
PARTY 243 DATE: FEBRUARY-1965
ENCLOSURE No 35 FIELD AREA REPORT



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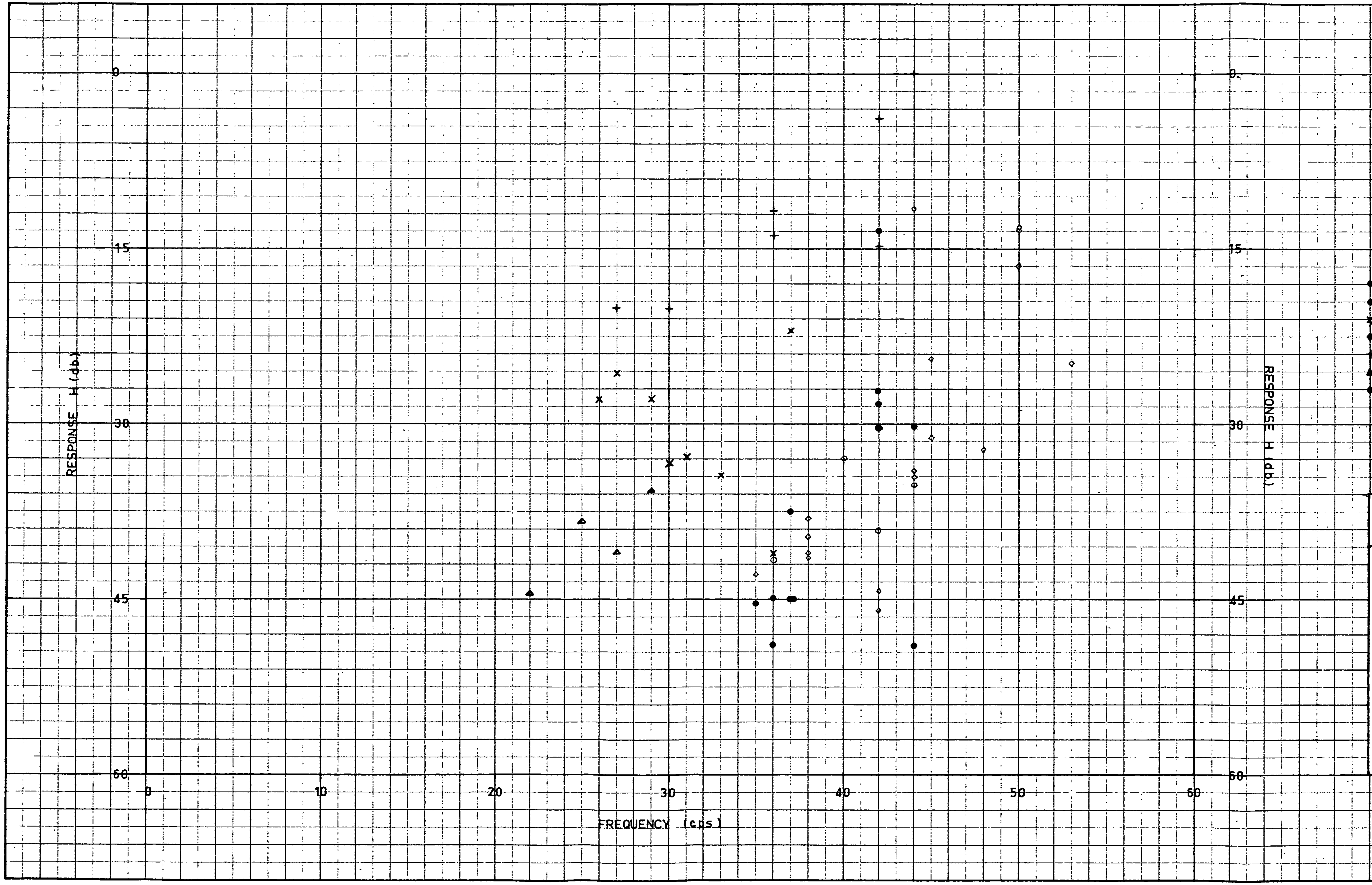
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

NOISE SPREAD 1.

RESPONSE—WAVE No. PLOT

LOCATION GAMBIER LSTN. 2
PARTY 243 LINE 1
PARTY CHIEF T.L.KENDALL
ENCLOSURE No. 36 FIELD AREA REPORT



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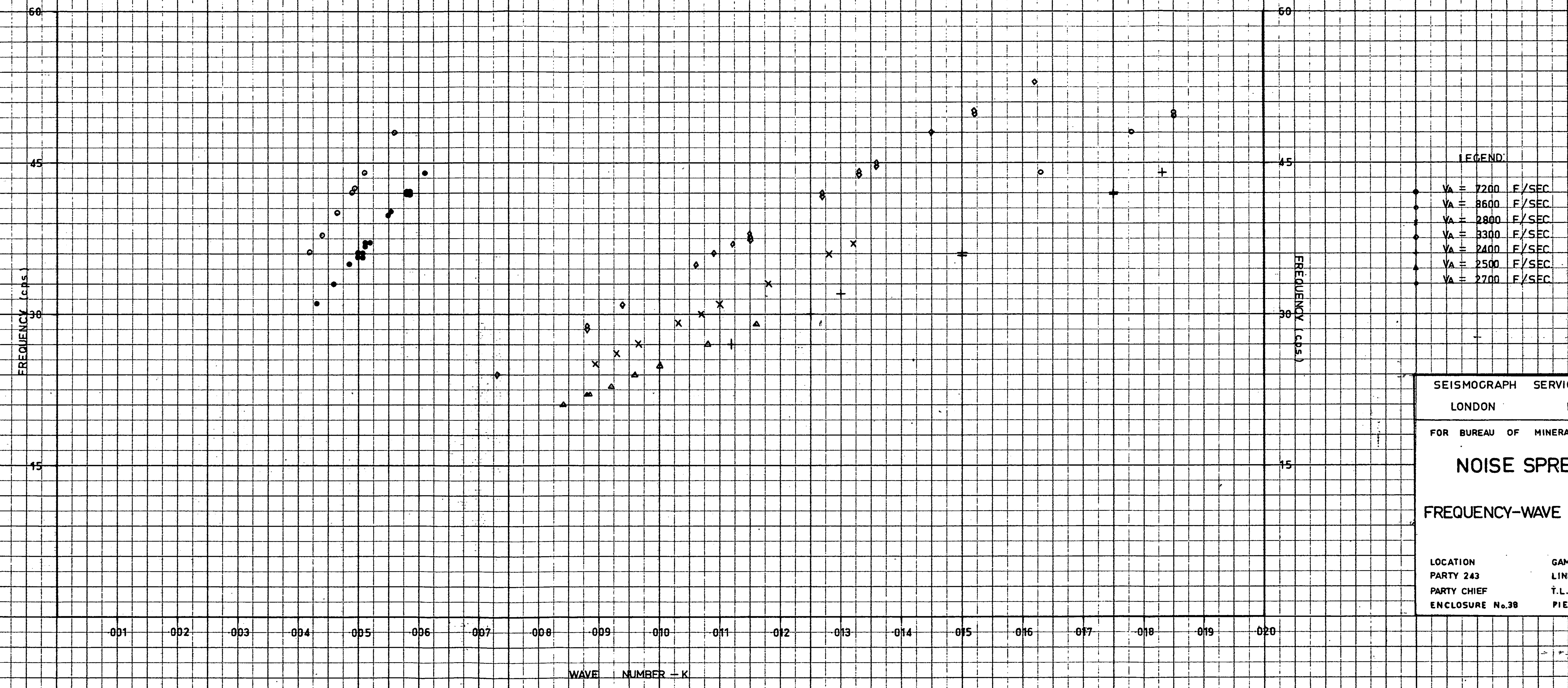
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

NOISE SPREAD 1.

RESPONSE-FREQUENCY PLOT

LOCATION GAMBIER LSTN. 2
PARTY 243 LINE 1
PARTY CHIEF T.L.KENDALL
ENCLOSURE No.37 FIELD AREA REPORT



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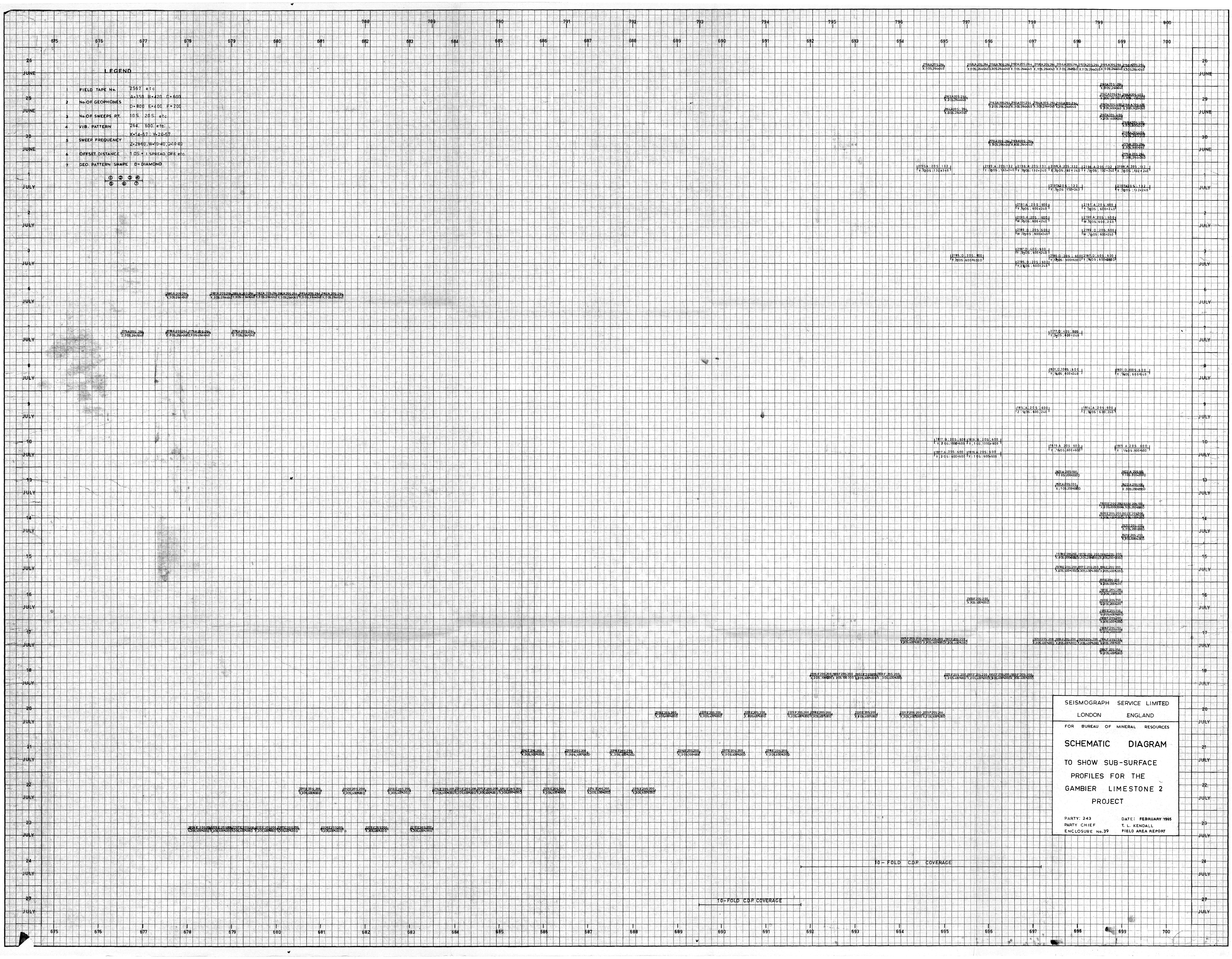
LONDON ENGLAND

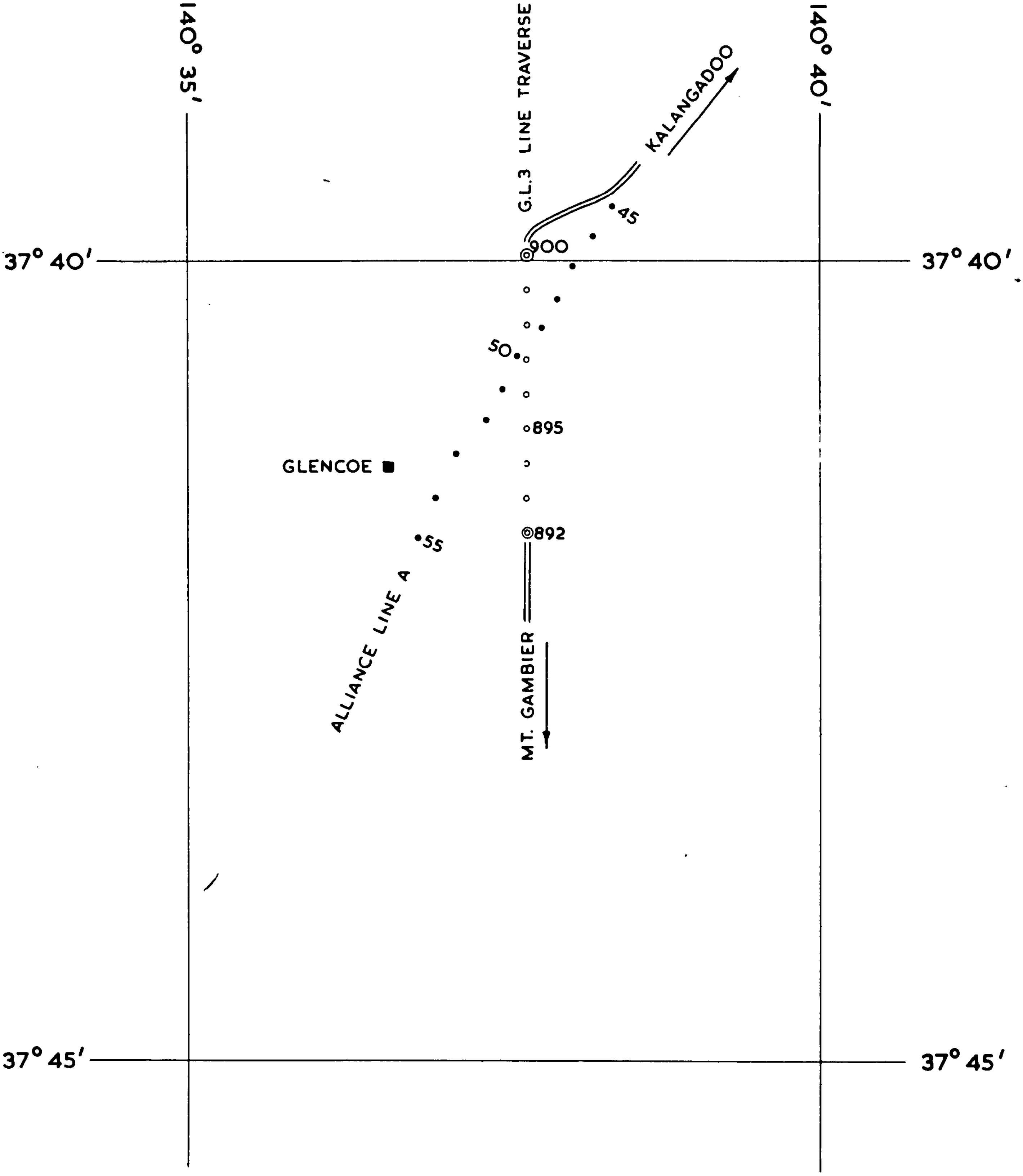
FOR BUREAU OF MINERAL RESOURCES

NOISE SPREAD 1

FREQUENCY-WAVE No. PLOT

LOCATION	GAMBIER LSTN. 2
PARTY 243	LINE 1
PARTY CHIEF	T.L. KENDALL
ENCLOSURE No.38	FIELD AREA REPORT


LEGEND
1 FIELD TAPE No. 2567 etc
2 No. OF GEOPHONES A=350 B=420 C=600 D=800 E=400 F=200
3 No. OF SWEEPS PT. 10S 20S etc
4 VIB. PATTERN 264. 600. etc.
5 SWEEP FREQUENCY X=14-57 Y=20-57 Z=28-80, W=10-40, Q=14-40
6 OFFSET DISTANCE 1 OS = 1 SPREAD OFF etc.
7 GEO. PATTERN SHAPE D=DIAMOND
① ② ③ ④
⑤ ⑥ ⑦
10-FOLD C.D.P. COVERAGE
10-FOLD C.D.P. COVERAGE
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
SCHEMATIC DIAGRAM
TO SHOW SUB-SURFACE PROFILES FOR THE GAMBIER LIMESTONE 2 PROJECT
PARTY: 243
PARTY CHIEF
ENCLOSURE No. 39
DATE: FEBRUARY 1965
T. L. KENDALL
FIELD AREA REPORT



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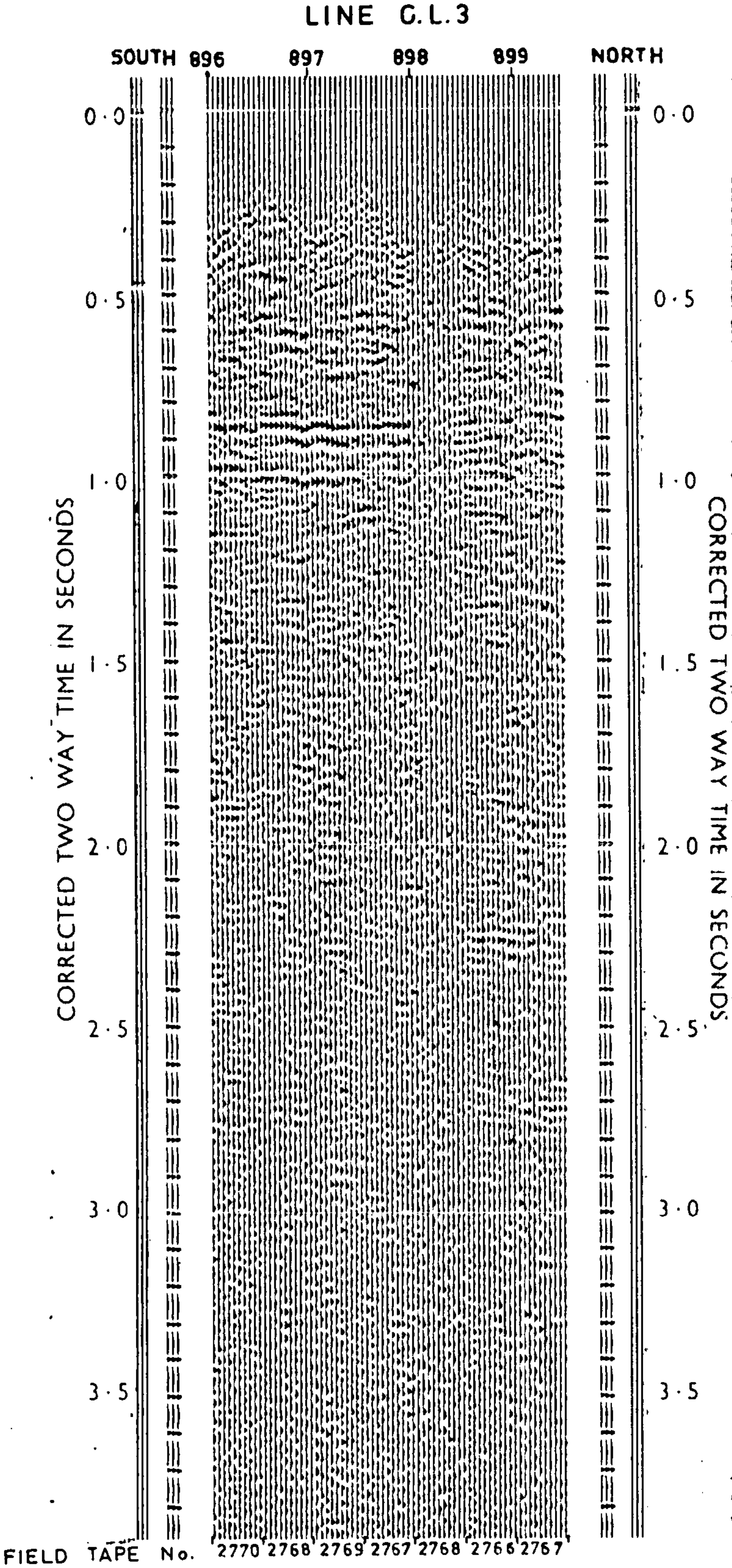
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES

V.P. LOCATION MAP

SCALE: 1 INCH TO 1 MILE

LOCATION	GAMBIER LIMESTONE 3
PARTY 243	FEBRUARY 1965
PARTY CHIEF	T. L. KENDALL
ENCLOSURE No 40	FIELD AREA REPORT

◎ MONUMENTED V.P.'S



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

GAMBIER LIMESTONE 3

LINE C.L.3 SP'S. 896 – 899

VELOCITY DISTRIBUTION	BEACHPORT No.1
WEATHERING VELOCITY (V_w)	–
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	7000 F/SEC.
WEATHERING METHOD	–
HORIZONTAL SCALE 1:2300'	DATUM M.S.L.+50'
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	132'
OFFSET DISTANCE	1386' – 2574'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14-57	No. OF SWEEPS 10
PLAYBACK FILTER	14 – 60
MIXING	–

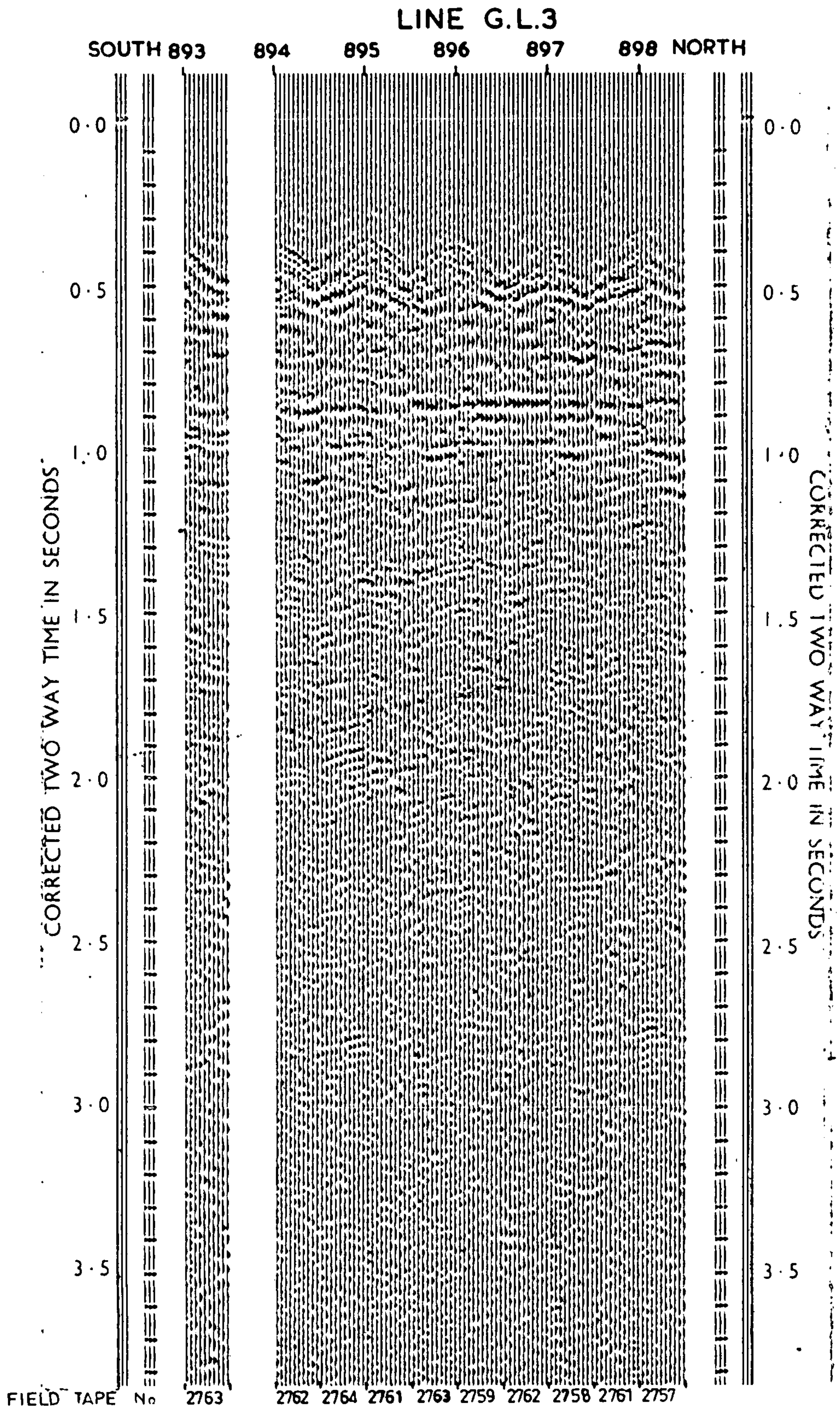
VIBRATOR PATTERN:

400' IN LINE

GEOPHONE PATTERN:

400'X200' RECTANGLE OF 350 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No.41	FIELD AREA REPORT



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VARIABLE AREA CROSS-SECTION
VIBROSEIS[©]
FOR BUREAU OF MINERAL RESOURCES

GAMBIER LIMESTONE 3

LINE G.L.3 S.P.S. 893 – 898

VELOCITY DISTRIBUTION	BEACHPORT No. 1
WEATHERING VELOCITY (V_w)	–
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	7000 FT/SEC
WEATHERING METHOD	–
HORIZONTAL SCALE 1": 2400'	DATUM M.S.L.+50'
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	132'
OFFSET DISTANCE	2706' - 3896'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14–57	No. OF SWEEPS 20
PLAYBACK FILTER	14-60
MIXING	—

VIBRATOR PATTERN: 200' IN LINE

GEOPHONE PATTERN:
400' X 400' DIAMOND OF 400 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No 42	FIELD AREA REPORT

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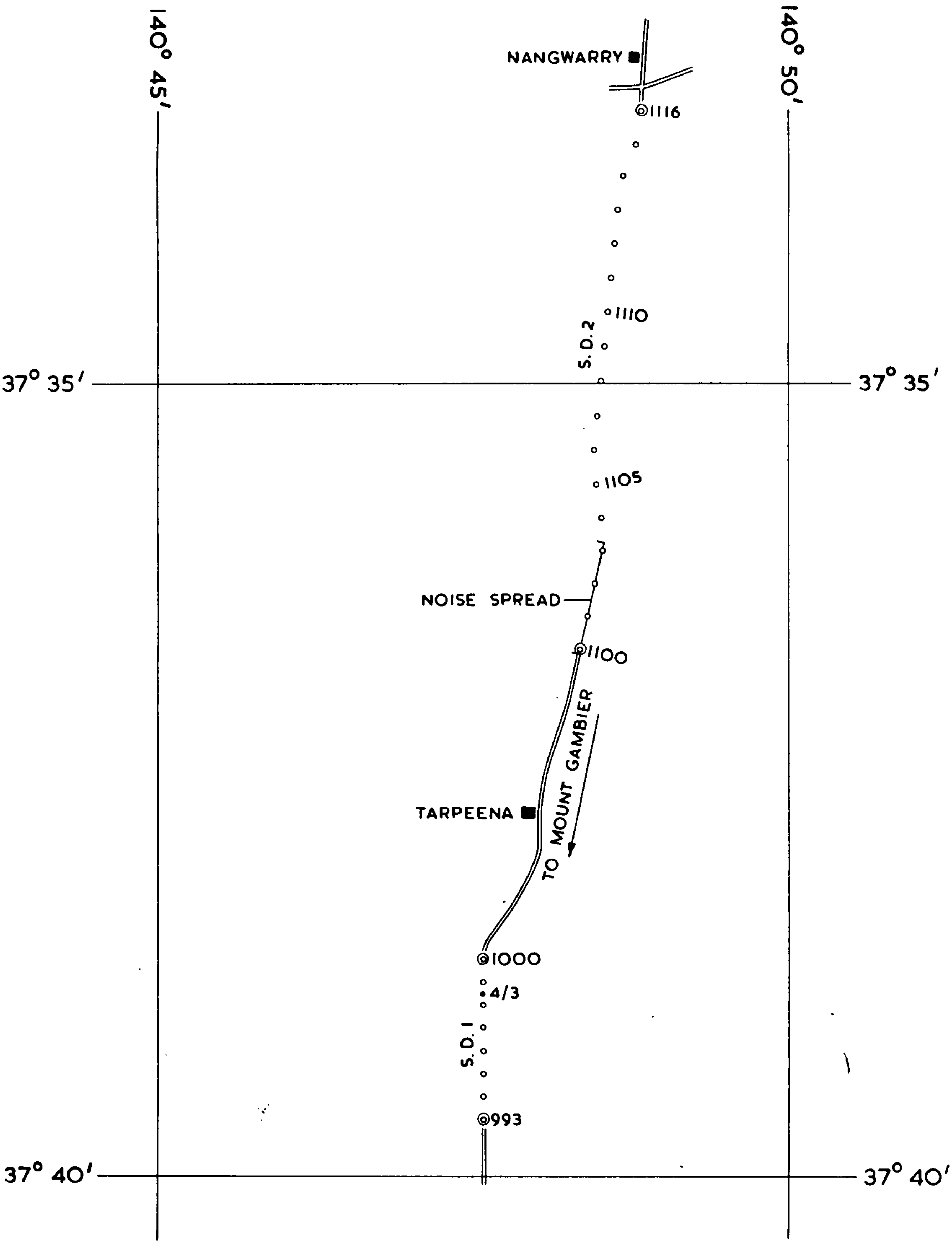


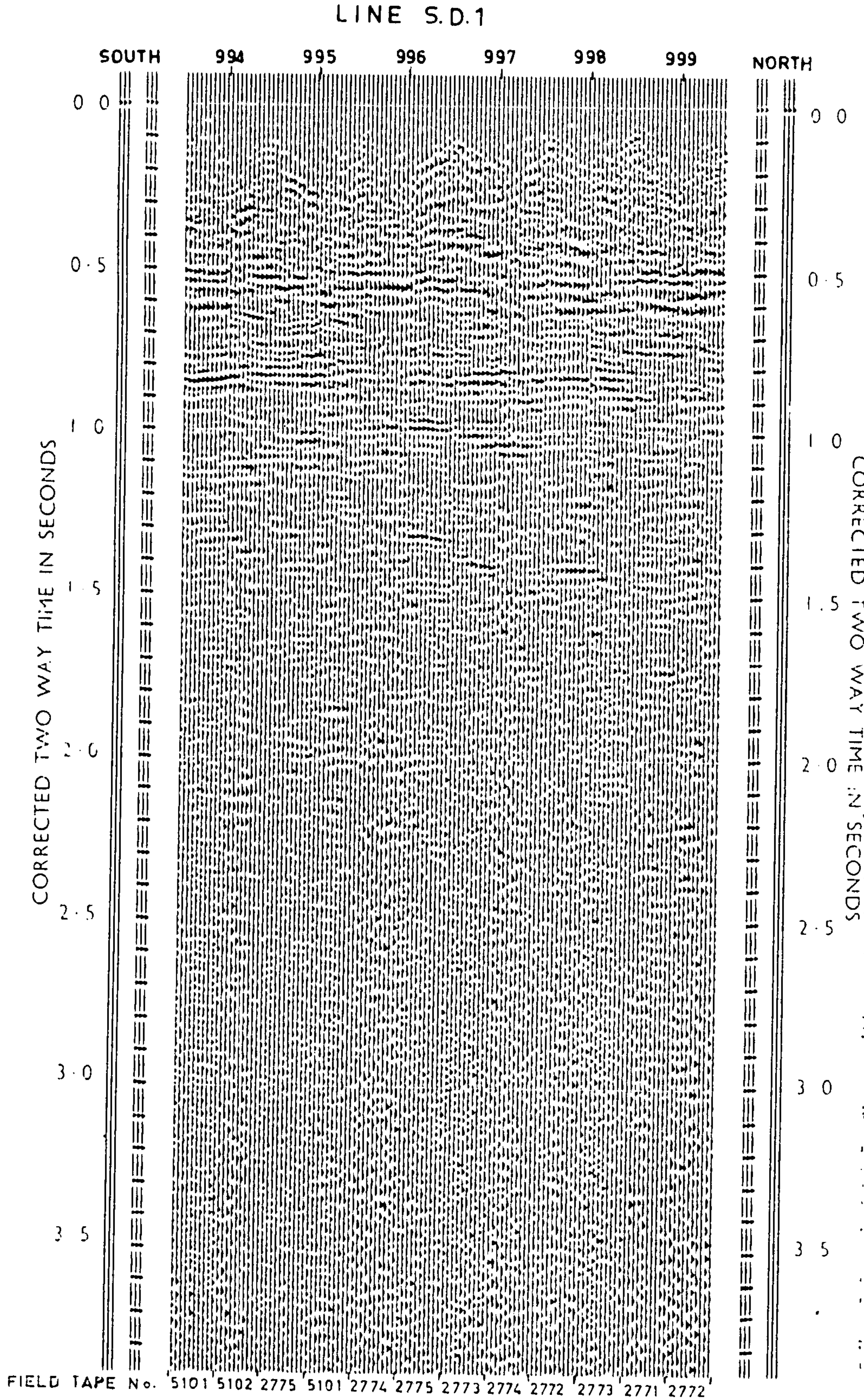
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES

V.P. LOCATION MAP

SCALE 1 INCH TO 1 MILE

LOCATION	S.D.1 & S.D.2
PARTY 243	FEBRUARY 1965
PARTY CHIEF	T. L. KENDALL
ENCLOSURE NO. 43	FIELD AREA REPORT

◎ MONUMENTED V.P.'S



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

SAND DUNES 1

LINE S.D. 1 SP'S. 994–999

VELOCITY DISTRIBUTION	BEACHPORT No.1
WEATHERING VELOCITY (V_w)	–
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	7000 F/SEC
WEATHERING METHOD	–
HORIZONTAL SCALE 1:1600	DATUM M.S.L.+50'
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	88'
OFFSET DISTANCE	924'–1716'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14-57	No. OF SWEEPS 10
PLAYBACK FILTER	14 – 60
MIXING	–

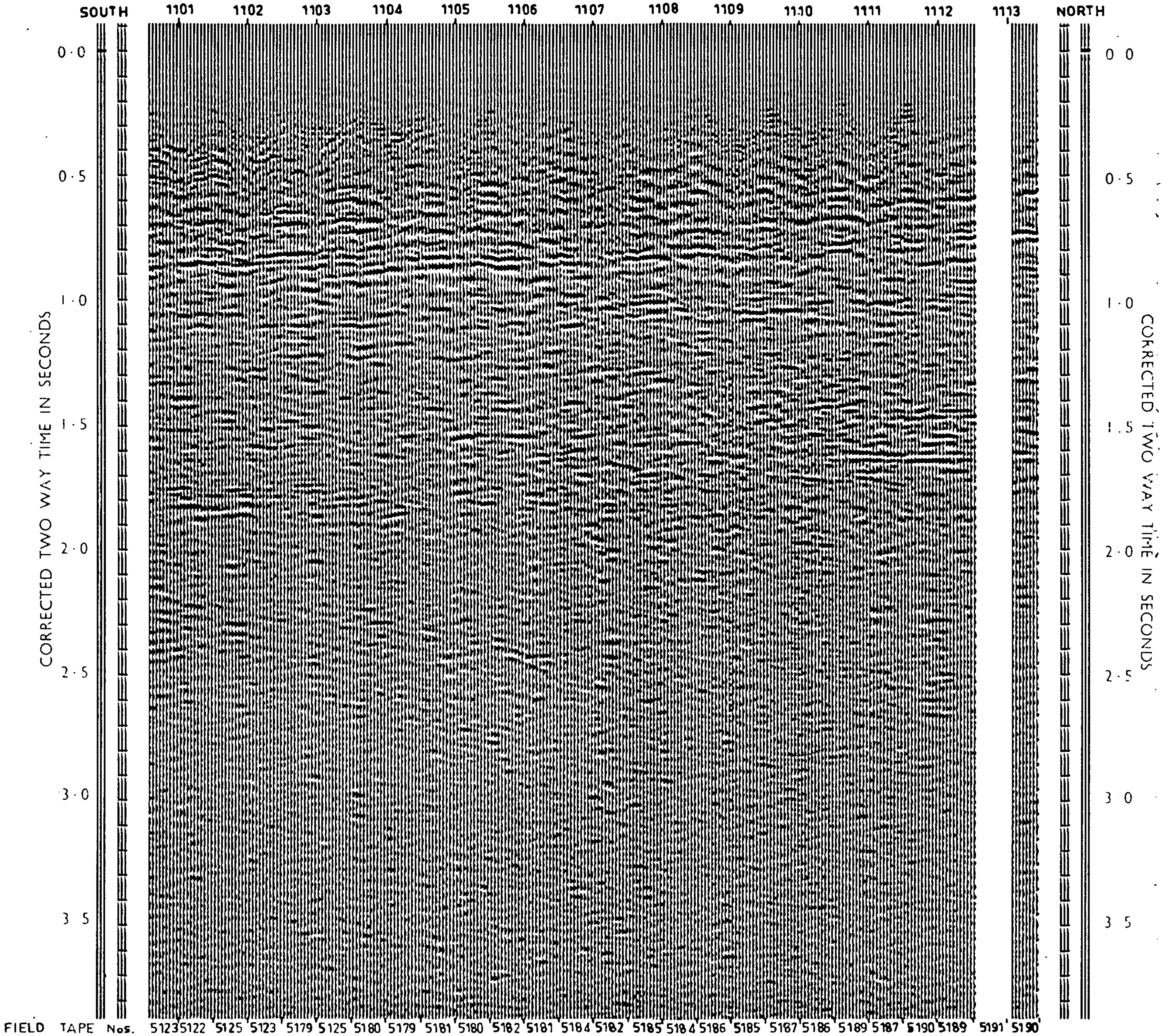
VIBRATOR PATTERN:
400' IN LINE

GEOPHONE PATTERN:
400' X 200' RECTANGLE OF 350 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No 44	FIELD AREA REPORT

®A TRADE MARK CONTINENTAL OIL CO.

LINE S. D. 2



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS*
FOR BUREAU OF MINERAL RESOURCES

SAND DUNES 2

LINE S. D. 2 S.P'S. 1101 – 1113

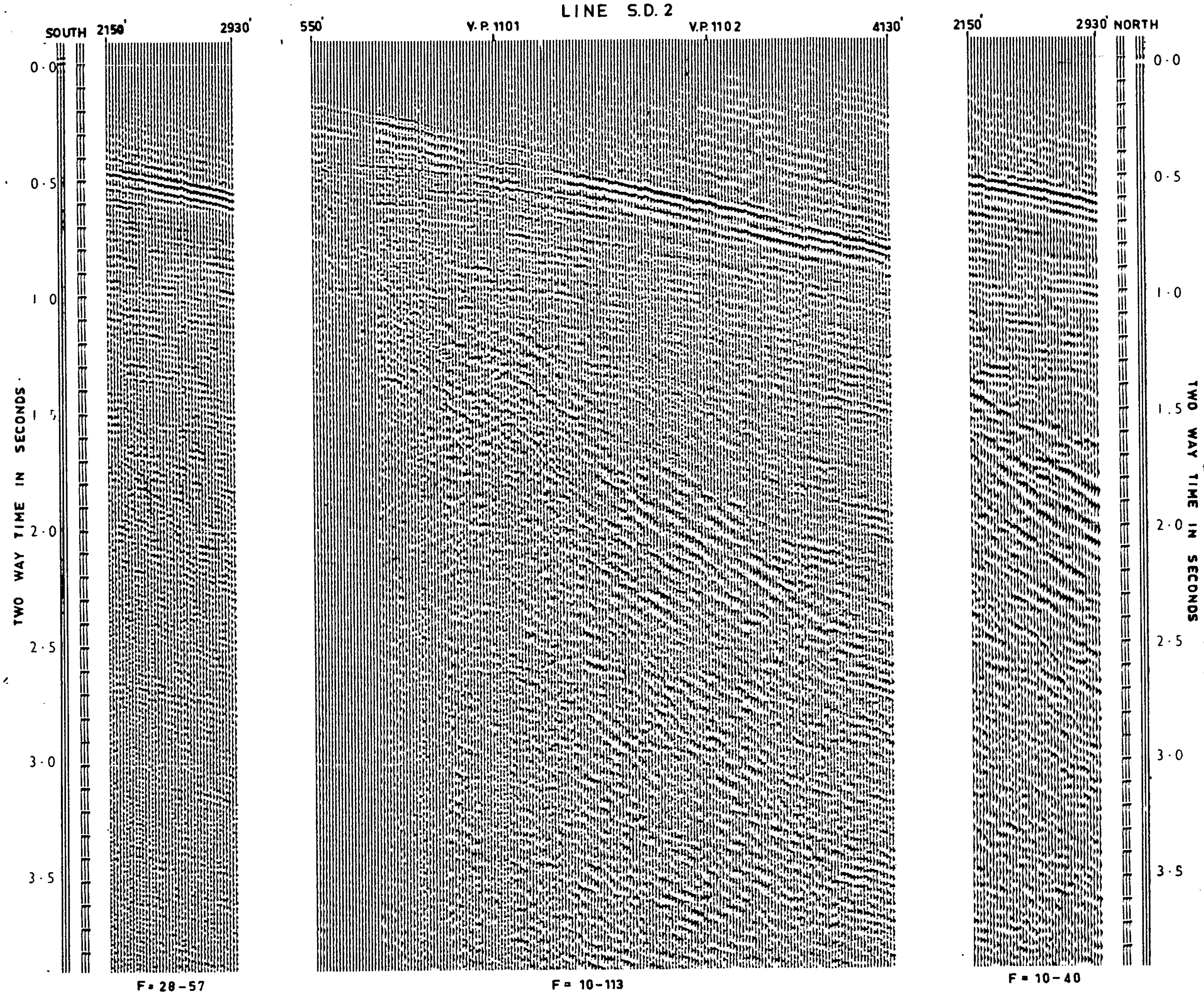
VELOCITY DISTRIBUTION	BEACHPORT No. 1
WEATHERING VELOCITY (Vw)	-
HORIZONTAL VELOCITY (Vh)	-
ELEVATION VELOCITY (Ve)	7000 F/SEC.
WEATHERING METHOD	-
HORIZONTAL SCALE 1: 2400'	DATUM M.S.L.
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	132'
OFFSET DISTANCE	1386' – 2574'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14-57	No. OF SWEEPS 20; 40
PLAYBACK FILTER	OUT-42
MIXING	3/2 COMPOSITED

VIBRATOR PATTERN:
400' IN LINE

GEOPHONE PATTERN:
400' X 200' RECTANGLE OF 400 GEOPHONES

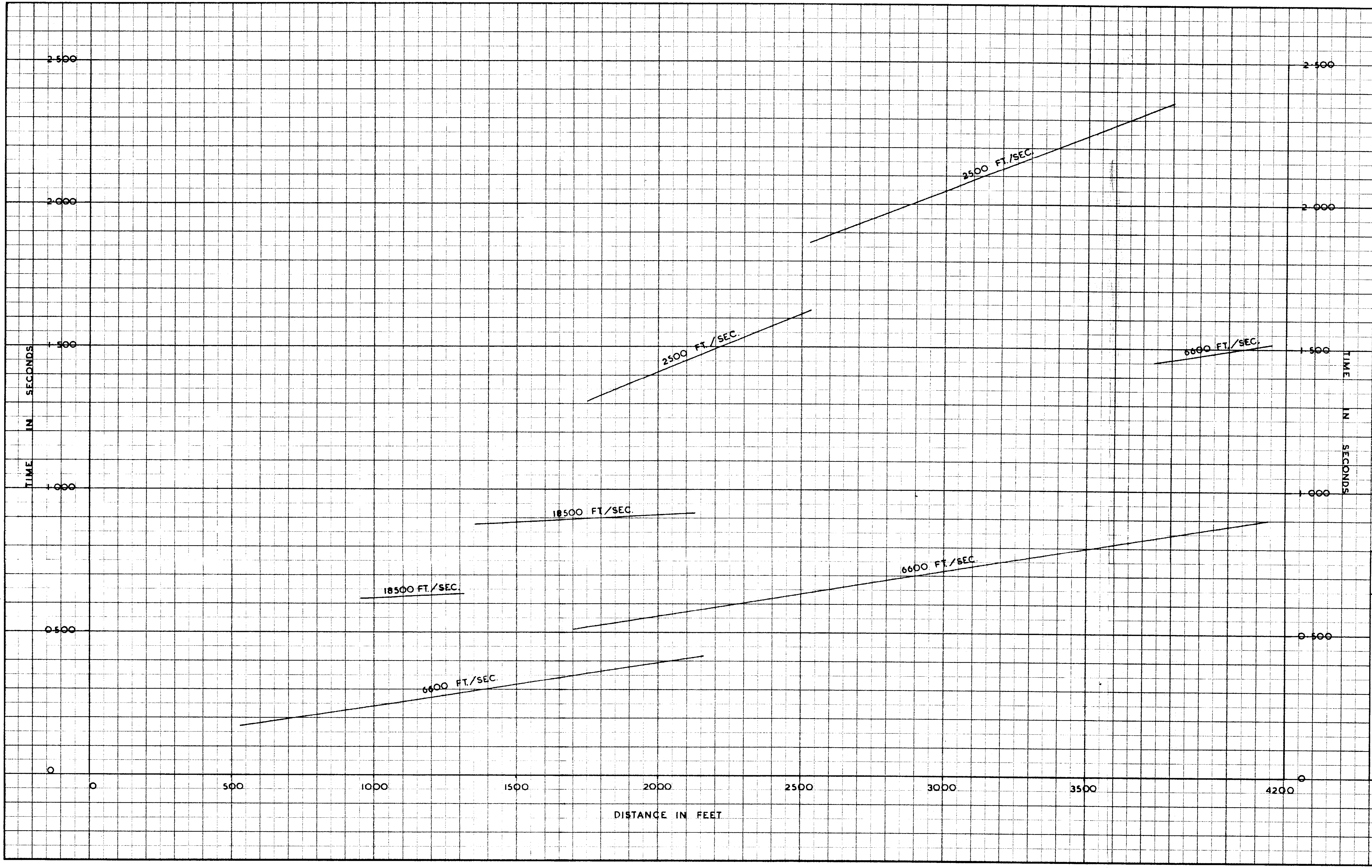
PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 45	FIELD AREA REPORT

*A TRADE MARK CONTINENTAL OIL CO



SEISMOGRAPH SERVICE LIMITED LONDON ENGLAND		
VARIABLE AREA CROSS-SECTION VIBROSEIS* FOR BUREAU OF MINERAL RESOURCES **NOISE SPREAD**		
LINE S.D. 2 S.P.'S.		
VELOCITY DISTRIBUTION		—
WEATHERING VELOCITY (V_w)		—
HORIZONTAL VELOCITY (V_h)		—
ELEVATION VELOCITY (V_e)		7000 F/SEC.
WEATHERING METHOD		—
HORIZONTAL SCALE	—	DATUM M.S.L.
TYPE OF PROFILING		IN LINE
TRACE INTERVAL		20'
OFFSET DISTANCE		550' – 4130'
No. AND TYPE OF VIBRATORS		1
SWEEP FREQUENCY S.B.S.		No. OF SWEEPS 1-10
PLAYBACK FILTER		OUT
MIXING		—
VIBRATOR PATTERN: ZERO		
GEOPHONE PATTERN: 10 GEOPHONES AT RIGHT ANGLES TO LINE		
PARTY 243		DATE FEBRUARY 1965
ENCLOSURE No. 46		FIELD AREA REPORT

*A TRADE MARK CONTINENTAL OIL CO.



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

NOISE SPREAD

TIME-DISTANCE PLOT

SCALE:
1 cm.: 100 ft. HORIZ.
1 cm.: 100 msec. VERT.

LOCATION	SAND DUNES 2
PARTY CHIEF	T. L. KENDALL
PARTY 243	FEBRUARY 1965
ENCLOSURE No. 47	FIELD AREA REPORT

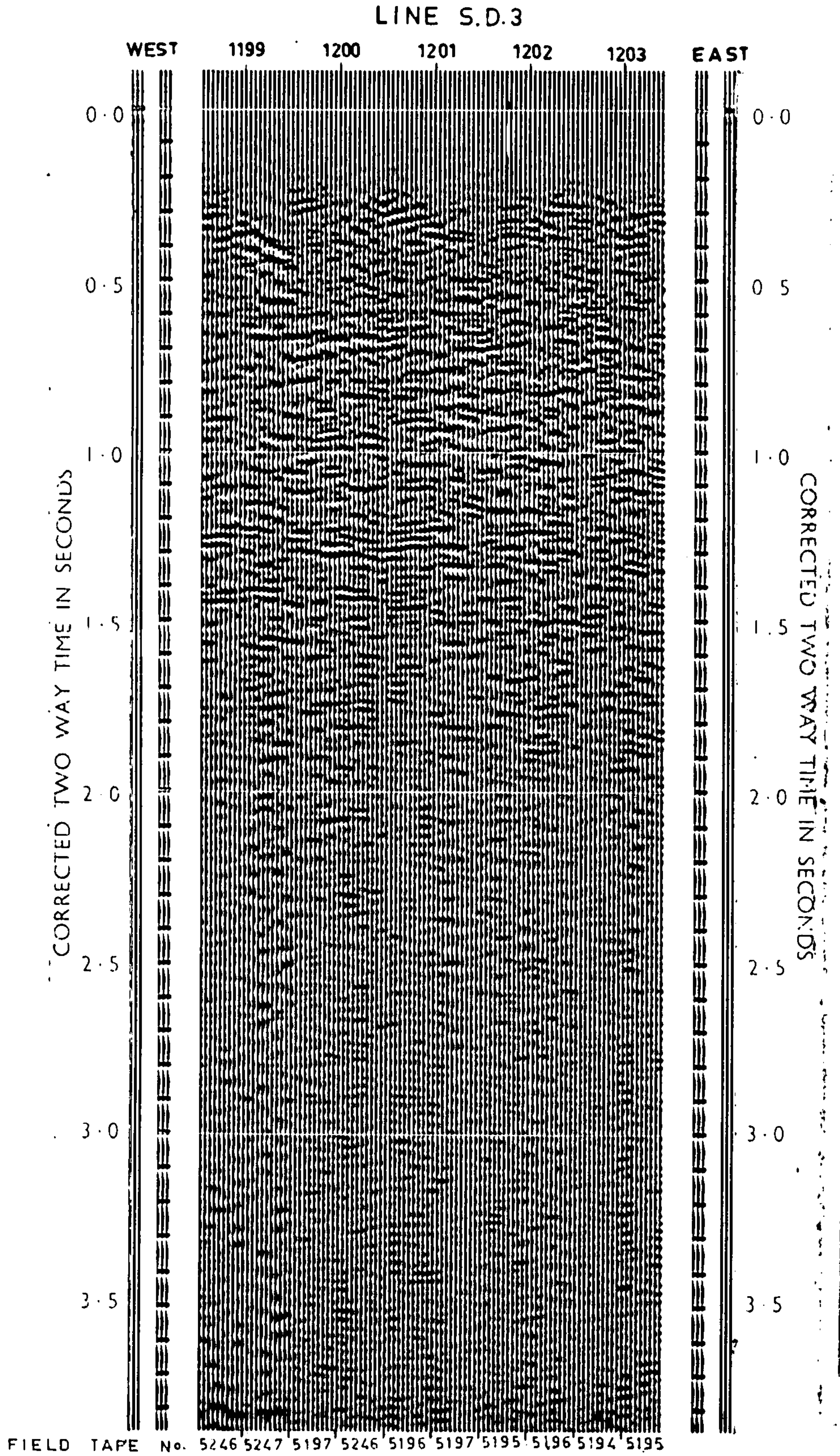
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

NOISE SPREAD
SAND DUNES 2

RESPONSE-WAVE No. PLOT
RESPONSE-FREQUENCY PLOT
FREQUENCY-WAVE No. PLOT

PARTY 243 DATE JULY-1964
PARTY CHIEF T. L. KENDALL
ENCLOSURE No.48 FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

SAND DUNES 3

LINE S. D. 3 S.P.'S. 1199 – 1203

VELOCITY DISTRIBUTION	BEACHPORT No.1
WEATHERING VELOCITY (V_w)	–
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	7000 F / SEC.
WEATHERING METHOD	–
HORIZONTAL SCALE 1 : 2400'	DATUM M.S.L.
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	132'
OFFSET DISTANCE	2706' – 3894'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14 – 57	No. OF SWEEPS 20
PLAYBACK FILTER	14 – 60
MIXING	3 / 2 COMPOSITED

VIBRATOR PATTERN:
400' IN LINE

GEOPHONE PATTERN:
400' X 180' RECTANGLE OF 400 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 49	FIELD AREA REPORT

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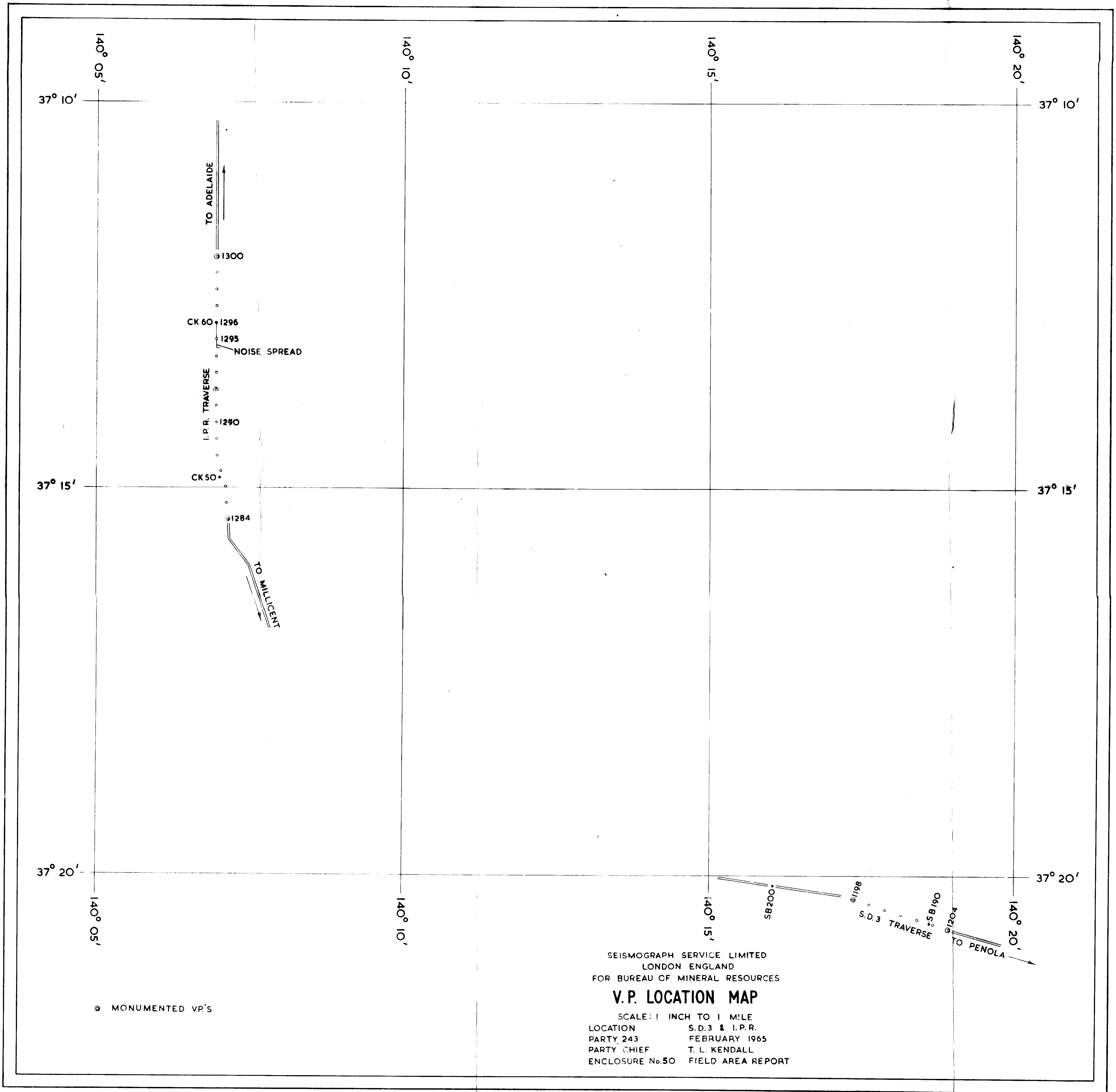
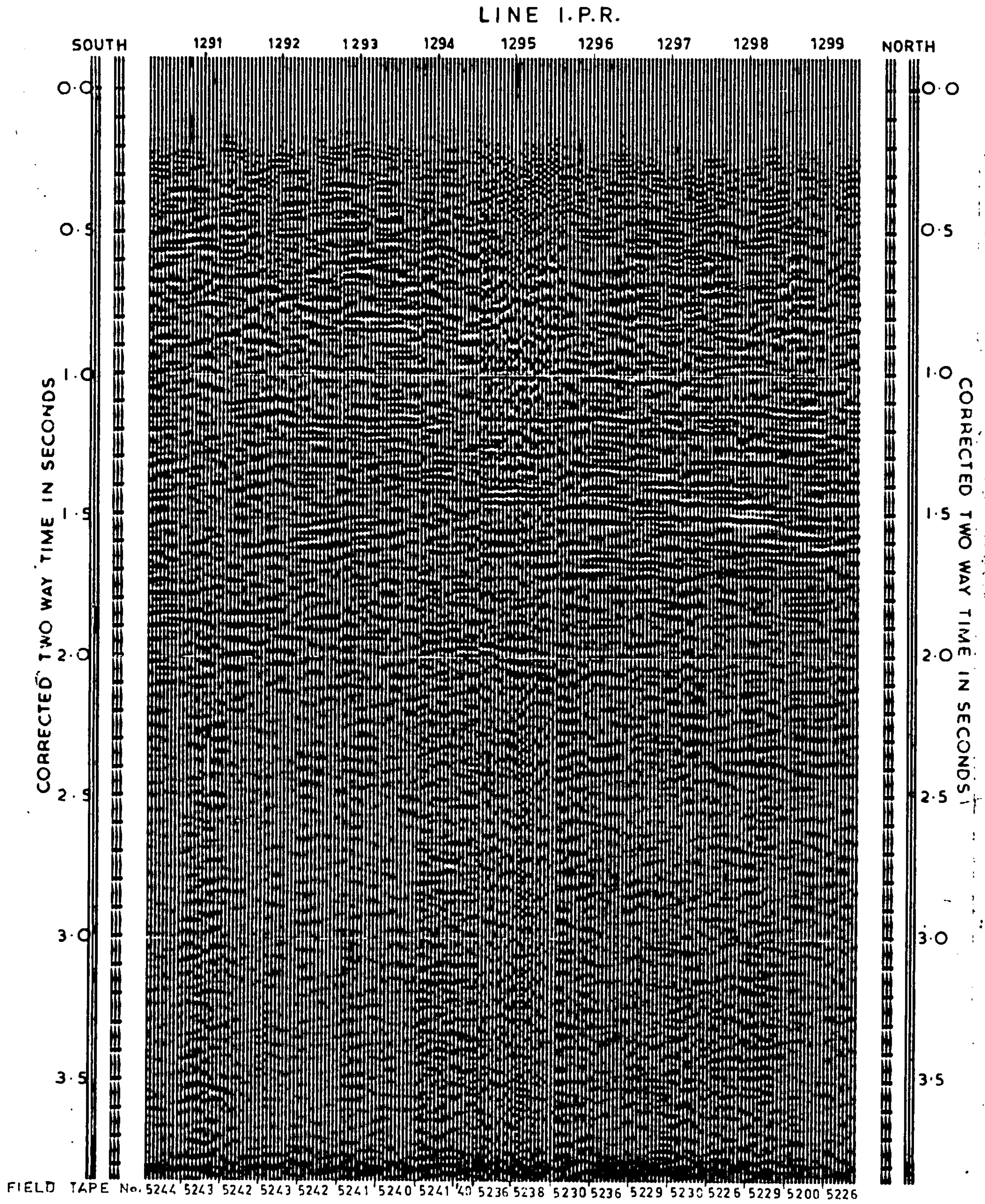


SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES

V.P. LOCATION MAP

SCALE: 1 INCH TO 1 MILE

LOCATION	S.D.3 & I.P.R.
PARTY 243	FEBRUARY 1965
PARTY CHIEF	T. L. KENDALL
ENCLOSURE No.50	FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

INTERDUNAL POOR REFLECTION

LINE I.P.R. SP'S. 1291 – 1299

VELOCITY DISTRIBUTION	BEACHPORT No.1
WEATHERING VELOCITY (V_w)	–
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	7000 F/SEC.
WEATHERING METHOD	–
HORIZONTAL SCALE 1" : 2400'	DATUM M.S.L.
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	132'
OFFSET DISTANCE	726' – 1254' & 1386' – 2574'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14 - 57	No. OF SWEEPS 10
PLAYBACK FILTER	14 – 60
MIXING	3/2 COMPOSITED

VIBRATOR PATTERN:

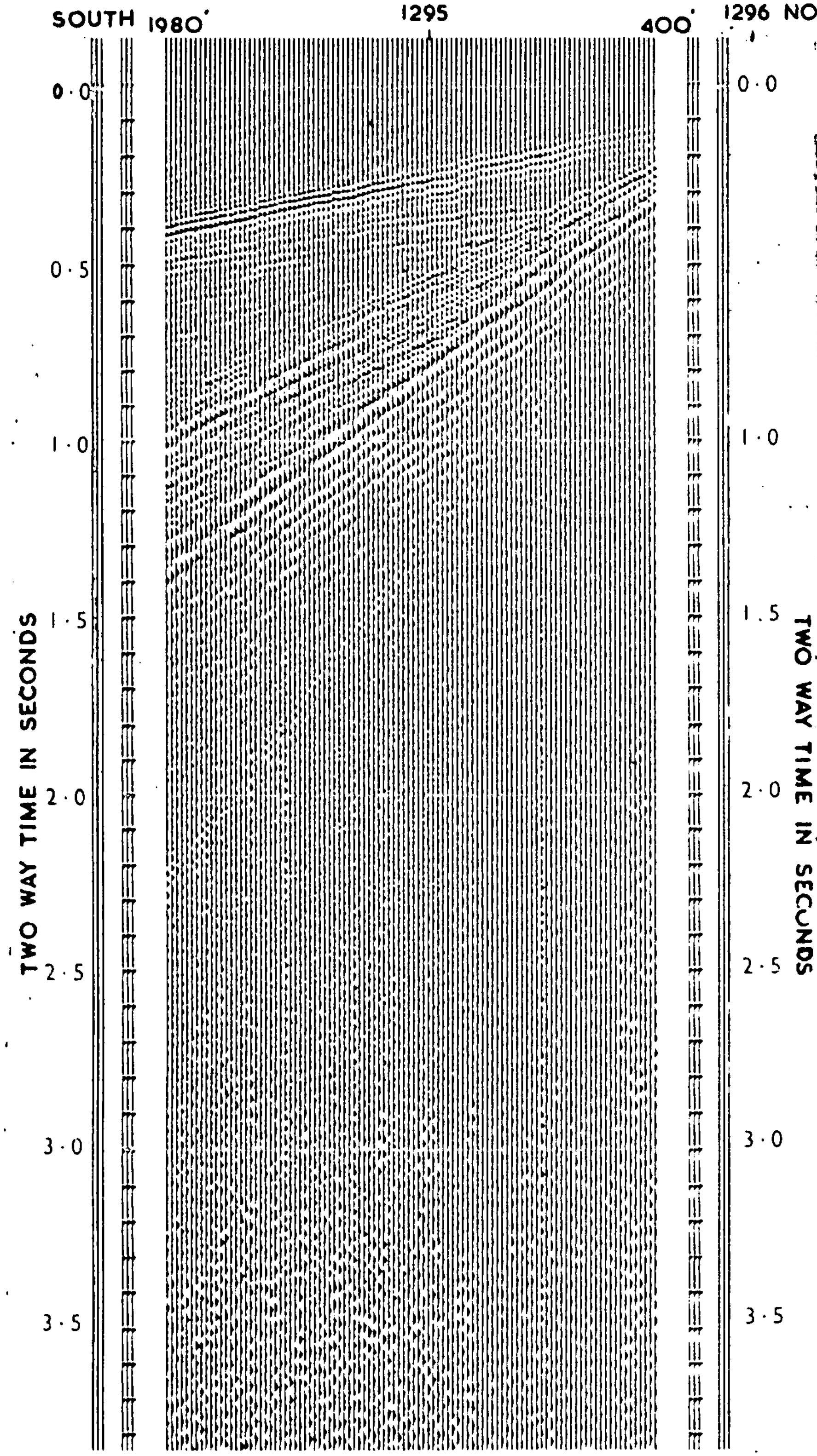
400' IN LINE

GEOPHONE PATTERN:

400' X 180' RECTANGLE OF 400 GEOPHONES

PARTY 243	DATE FEBRUARY 1969
ENCLOSURE No. 51	FIELD AREA REPORT

I.P.R. NOISE SPREAD



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

INTERDUNAL POOR REFLECTION AREA

LINE I.P.R. SP'S. 1296

VELOCITY DISTRIBUTION	
WEATHERING VELOCITY (V_w)	
HORIZONTAL VELOCITY (V_h)	
ELEVATION VELOCITY (V_e)	
WEATHERING METHOD	
HORIZONTAL SCALE 1": 700'	DATUM
TYPE OF PROFILING	NOISE SPREAD TRANSP'D
TRACE INTERVAL	20'
OFFSET DISTANCE	400'- 1980'
No. AND TYPE OF VIBRATORS	1
SWEEP FREQUENCY 10-113	No. OF SWEEPS
PLAYBACK FILTER	OUT
MIXING	NIL

VIBRATOR PATTERN: NIL

GEOPHONE PATTERN: 50 GEOPHONES BUNCHED

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 52	FIELD AREA REPORT

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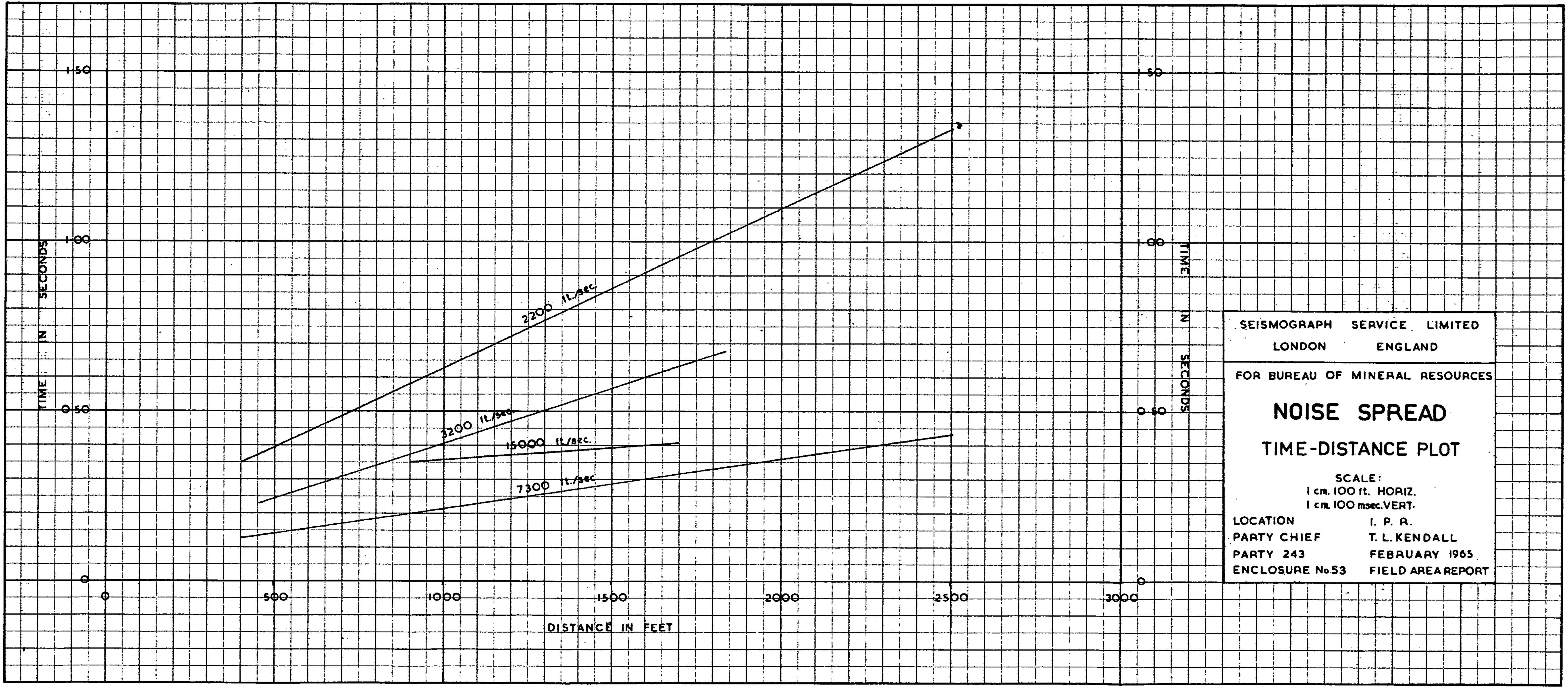


1·50
1·00
0·50
0
TIME IN SECONDS
2200 ft./sec.
3200 ft./sec.
15000 ft./sec.
7300 ft./sec.
0
500
1000
1500
2000
2500
3000
DISTANCE IN FEET
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
NOISE SPREAD
TIME-DISTANCE PLOT
SCALE:
1 cm. 100 ft. HORIZ.
1 cm. 100 msec. VERT.
LOCATION I. P. R.
PARTY CHIEF T. L. KENDALL
PARTY 243 FEBRUARY 1965
ENCLOSURE No 53 FIELD AREA REPORT

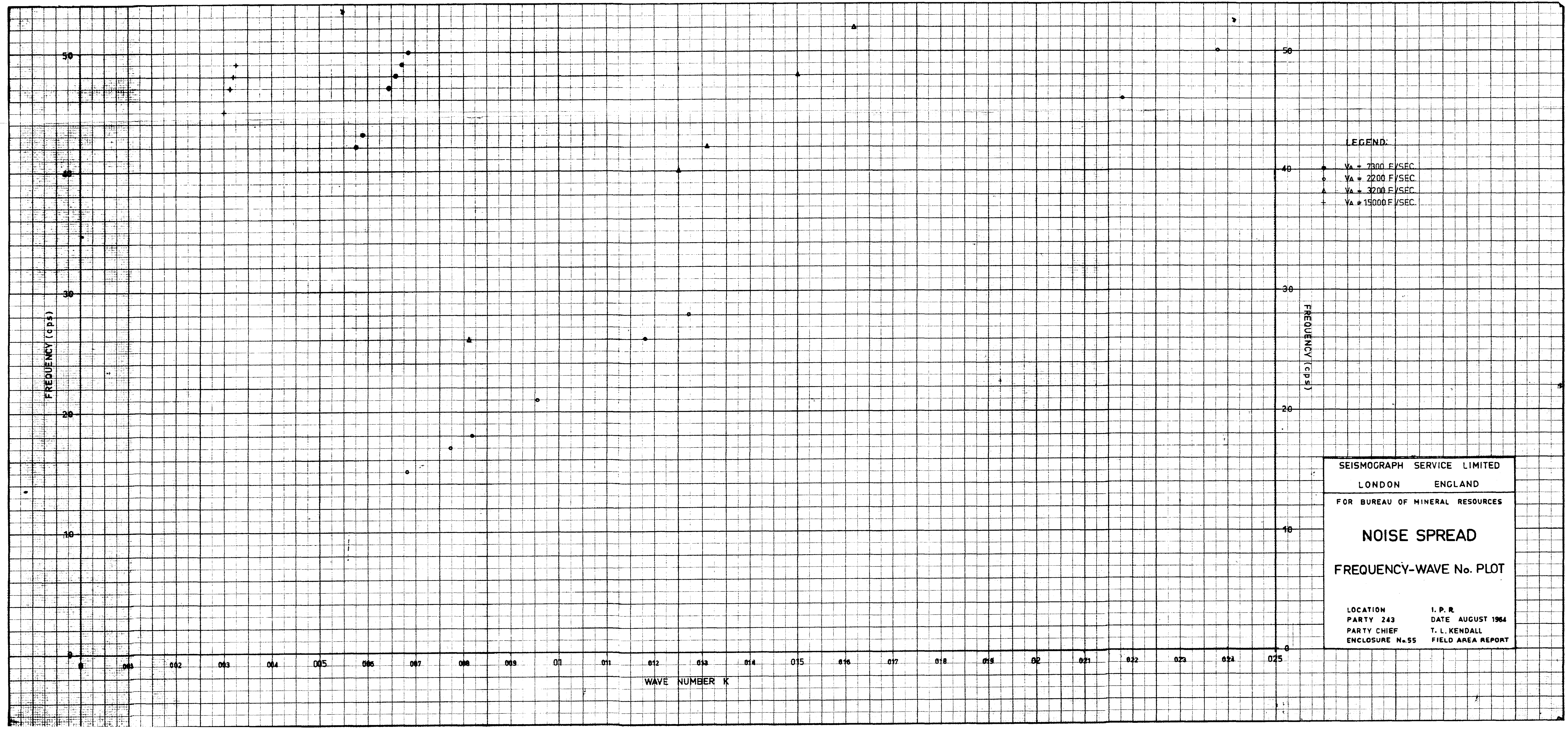
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

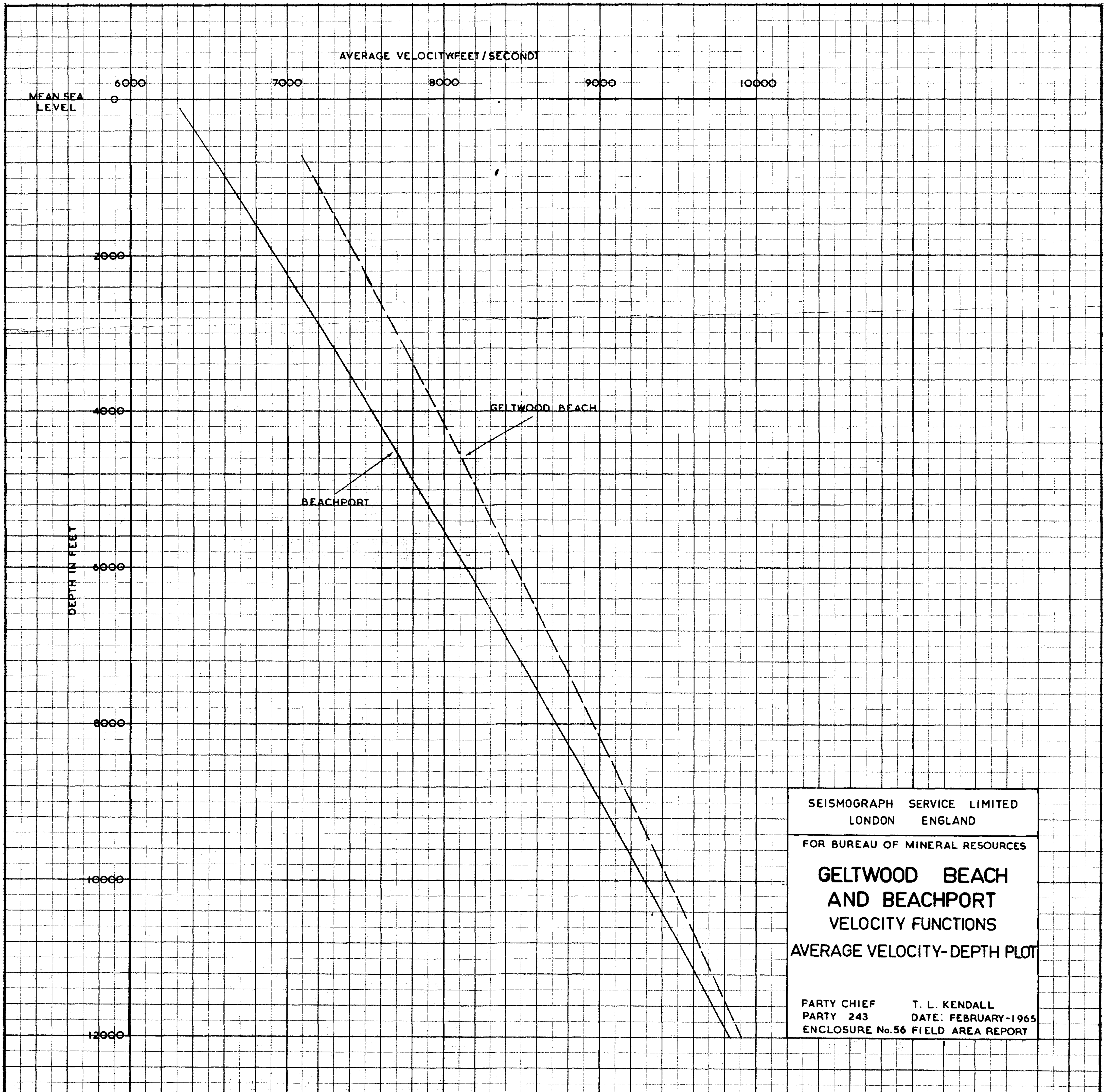
FOR BUREAU OF MINERAL RESOURCES

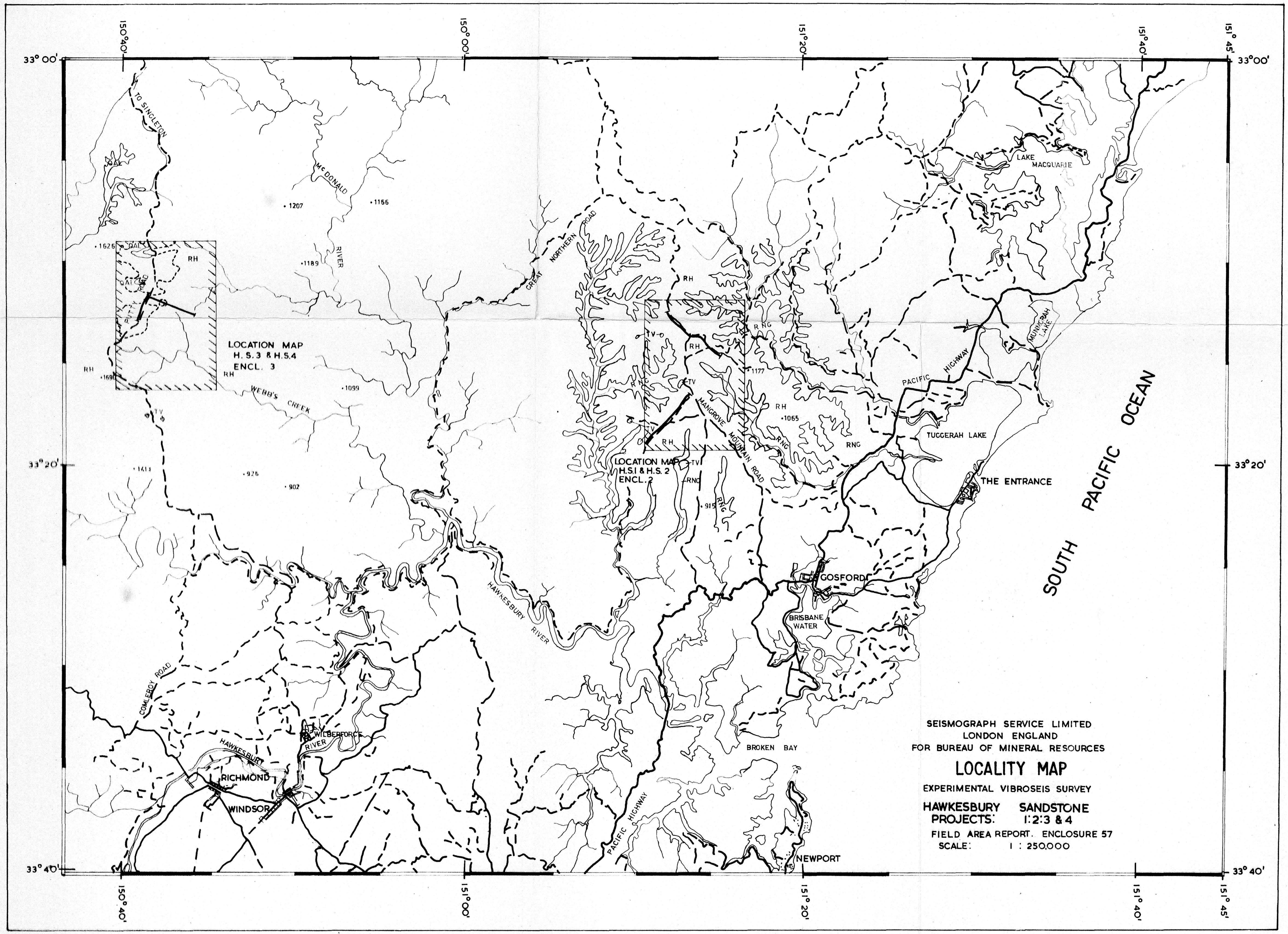
NOISE SPREAD

RESPONSE-FREQUENCY PLOT
RESPONSE-WAVE No. PLOT

LOCATION	I.P.R.
PARTY 243	DATE AUGUST 1964
PARTY CHIEF	T.L. KENDALL
ENCLOSURE No.54	FIELD AREA REPORT

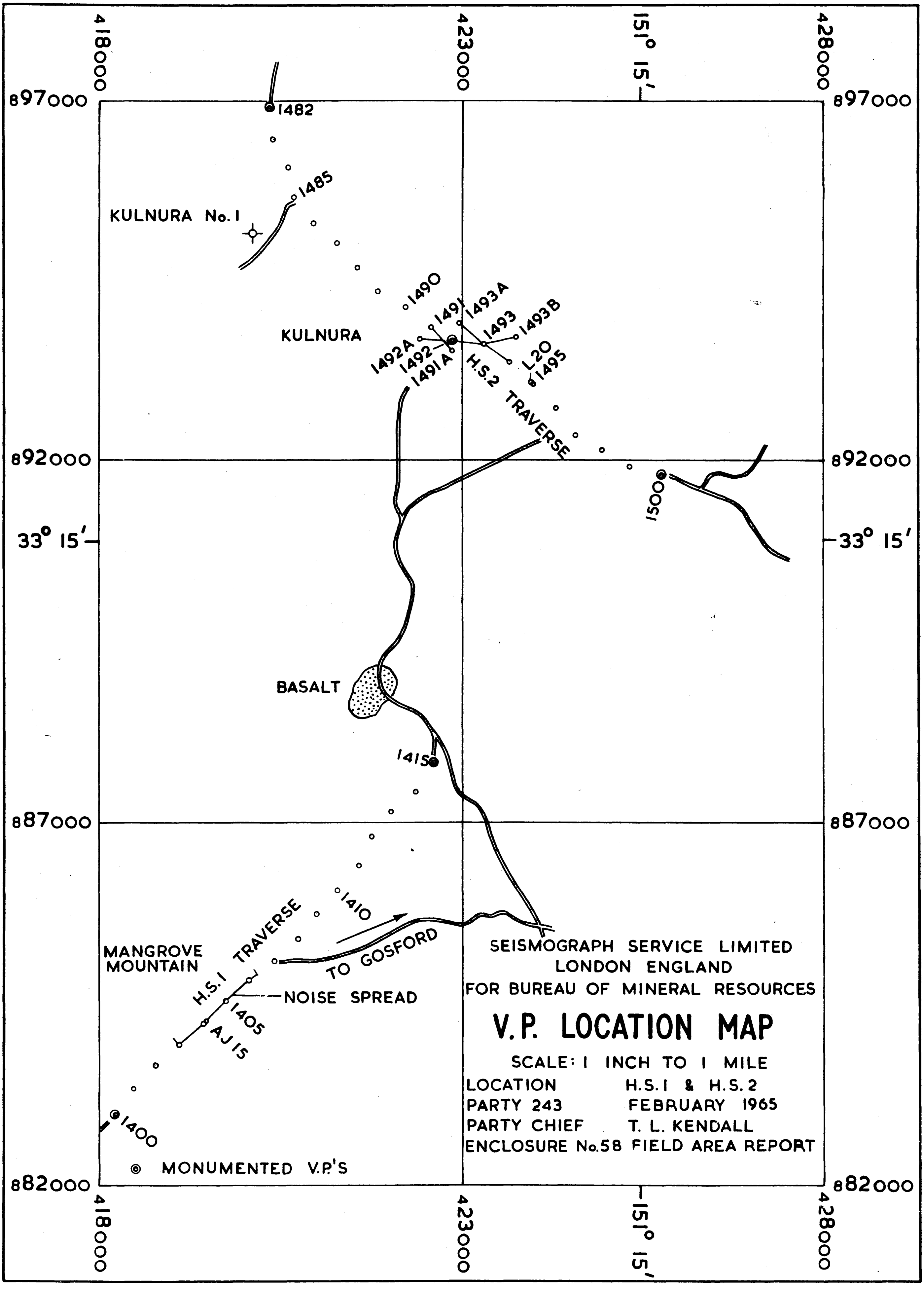

FREQUENCY (cps)
50
40
30
20
10
0
0
001
002
003
004
005
006
007
008
009
01
011
012
013
014
015
016
017
018
019
02
021
022
023
024
025
WAVE NUMBER K
LEGEND:
VA = 7300 F/SEC.
VA = 2200 F/SEC.
VA = 3200 F/SEC.
VA = 15000 F/SEC.
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
NOISE SPREAD
FREQUENCY-WAVE No. PLOT
LOCATION I. P. R.
PARTY 243 DATE AUGUST 1964
PARTY CHIEF T. L. KENDALL
ENCLOSURE No.55 FIELD AREA REPORT

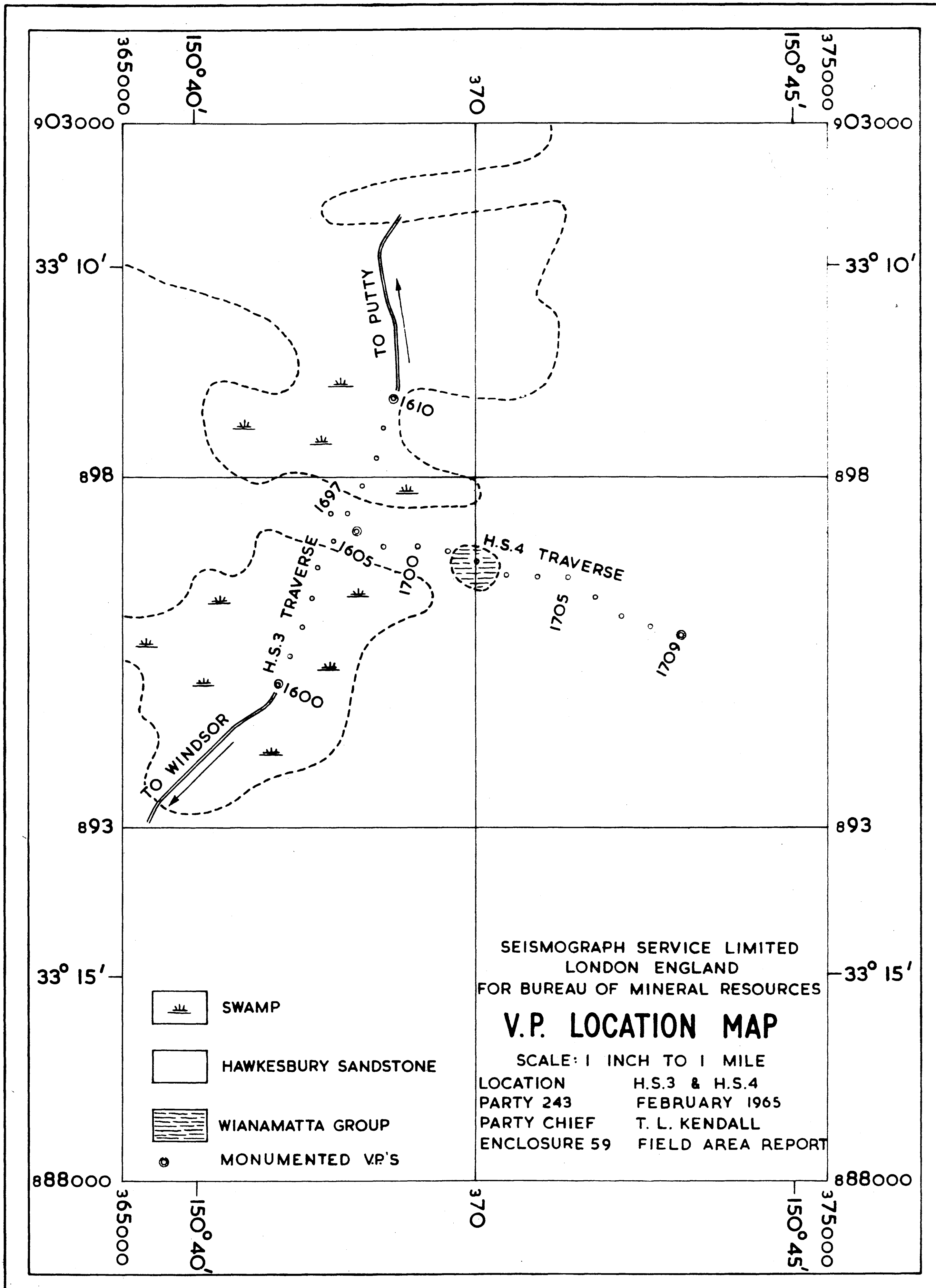

AVERAGE VELOCITY (FEET / SECOND)
6000
7000
8000
9000
10000
MEAN SEA LEVEL
2000
4000
6000
8000
10000
12000
DEPTH IN FEET
GELTWOOD BEACH
BEACHPORT
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
GELTWOOD BEACH AND BEACHPORT
VELOCITY FUNCTIONS
AVERAGE VELOCITY-DEPTH PLOT
PARTY CHIEF T. L. KENDALL
PARTY 243
DATE: FEBRUARY-1965
ENCLOSURE No. 56
FIELD AREA REPORT

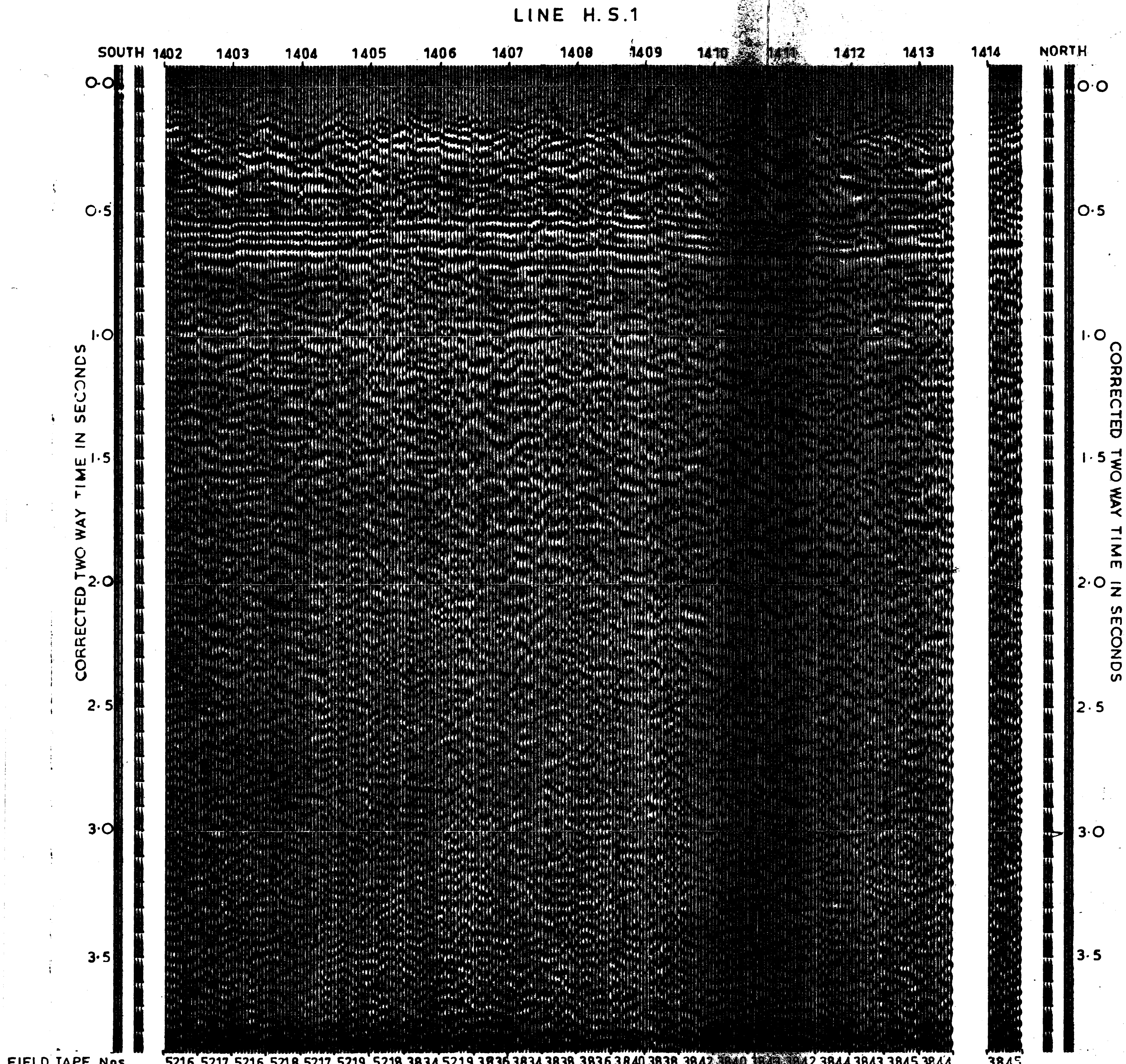


THE GEOLOGICAL DEMARKATIONS SHOWN ON THIS MAP HAVE BEEN ABSTRACTED FROM GEOLOGICAL SURVEY OF N.S.W. SYDNEY SHEET SI 56-5

RH	HAWKESBURY SANDSTONE
RNG	NARRABEEN GROUP GOSFORD FORMATION
TV	BASALT
QAL	ALLUVIUM
	SWAMP
	WIANAMATTA GROUP


418000
423000
151° 15'
428000
897000
892000
887000
882000
33° 15'
1482
1485
KULNURA No. 1
1490
1491
1493A
1493
1493B
KULNURA
1492A
1492
1491A
H.S.2 TRAVERSE
L20
1495
1500
BASALT
1415
1410
MANGROVE MOUNTAIN
H.S.1 TRAVERSE
TO GOSFORD
NOISE SPREAD
1405
AJ15
1400
MONUMENTED V.P.'S
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
V.P. LOCATION MAP
SCALE: 1 INCH TO 1 MILE
LOCATION H.S.1 & H.S.2
PARTY 243 FEBRUARY 1965
PARTY CHIEF T. L. KENDALL
ENCLOSURE No.58 FIELD AREA REPORT


365000
150° 40'
370
150° 45'
375000
903000
33° 10'
898
893
33° 15'
888000
TO PUTTY
TO WINDSOR
1610
1697
1605
1700
1600
1705
1709
H.S.3 TRAVERSE
H.S.4 TRAVERSE
SWAMP
HAWKESBURY SANDSTONE
WIANAMATTA GROUP
MONUMENTED V.P'S
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
V.P. LOCATION MAP
SCALE: 1 INCH TO 1 MILE
LOCATION H.S.3 & H.S.4
PARTY 243 FEBRUARY 1965
PARTY CHIEF T. L. KENDALL
ENCLOSURE 59 FIELD AREA REPORT



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VARIABLE AREA CROSS-SECTION
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HAWKESBURY SANDSTONE 1

LINE H.S.1 SP'S. 1402 – 1414

VELOCITY DISTRIBUTION	Vi=12000+·6z		
WEATHERING VELOCITY (Vw)	3000 FT/SEC.		
HORIZONTAL VELOCITY (Vh)	–		
ELEVATION VELOCITY (Ve)	10000 FT./SEC.		
WEATHERING METHOD	–		
HORIZONTAL SCALE	1":2400'	DATUM	M.S.L.
TYPE OF PROFILING	TRANSPOSED		
TRACE INTERVAL	132'		
OFFSET DISTANCE	1386'-2574'		
No. AND TYPE OF VIBRATORS	3		
SWEEP FREQUENCY	10-40	No. OF SWEEPS	10
PLAYBACK FILTER	OUT - 42		
MIXING	–		

VIBRATOR PATTERN:
600' IN LINE

GEOPHONE PATTERN:
600' X 200' RECTANGLE OF 360 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 60	FIELD AREA REPORT

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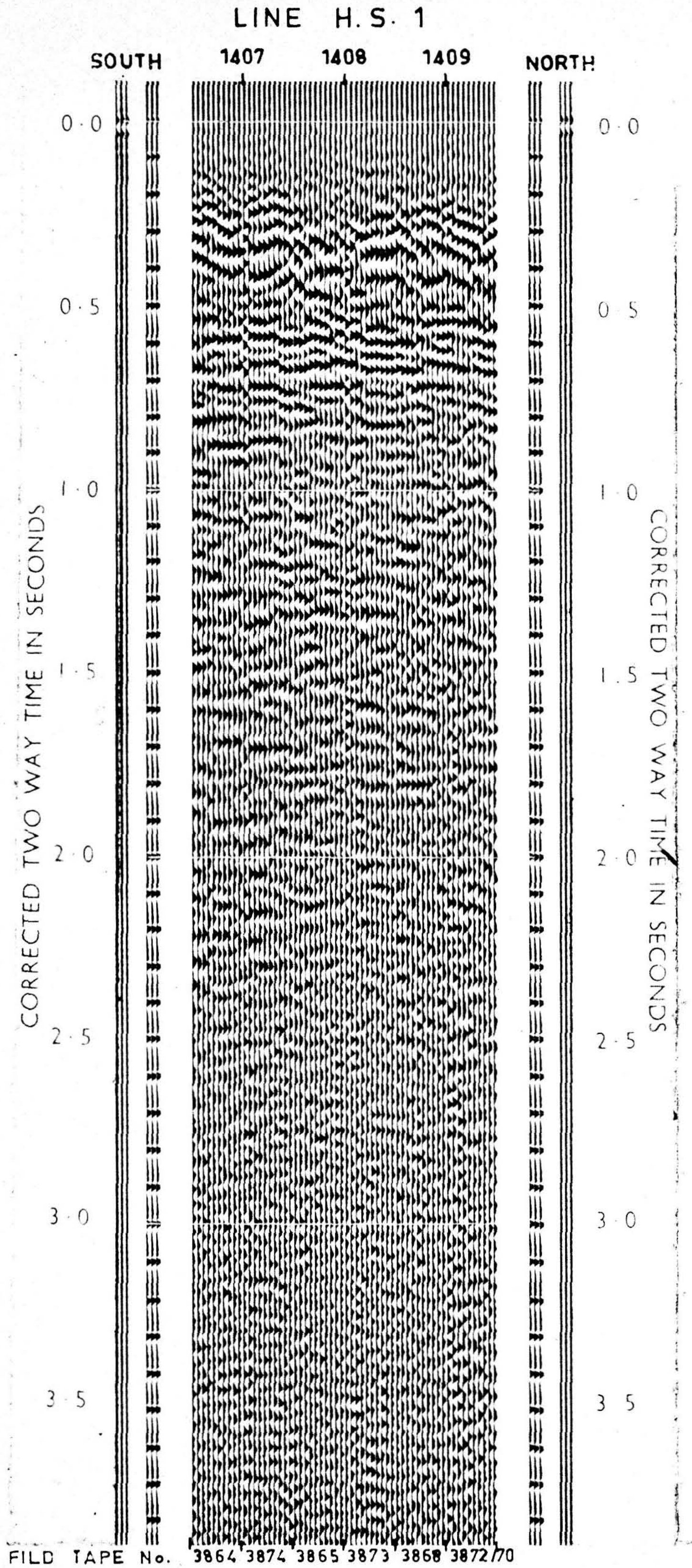

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LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

HAWKESBURY SANDSTONE 1

LINE H.S. 1 SP'S. 1407 - 1409

VELOCITY DISTRIBUTION	Vi = 12000 + ·6 z
WEATHERING VELOCITY (V_w)	3000 F/SEC.
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	10000 F/SEC.
WEATHERING METHOD	–
HORIZONTAL SCALE 1 : 2400	DATUM M.S.L. – 800'
TYPE OF PROFILING	TRANSPOSED
GEOPHONE INTERVAL	132'
OFFSET DISTANCE	2706' – 3894'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 10 - 40	No. OF SWEEPS 20
PLAYBACK FILTER	OUT - 42
MIXING	–

VIBRATOR PATTERN:

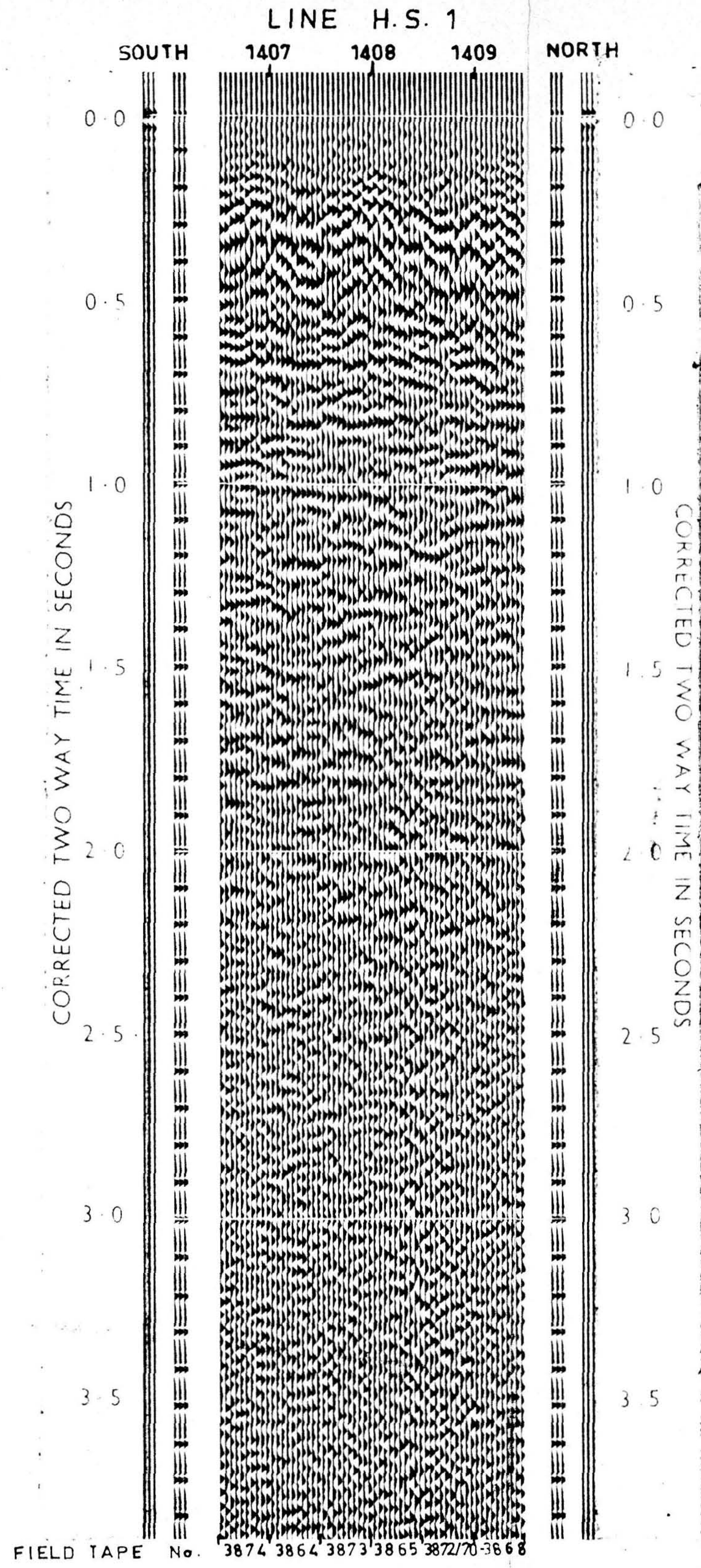
600' IN LINE

GEOPHONE PATTERN:

600' X 200' RECTANGLE OF 360 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 61	FIELD AREA REPORT

®A TRADE MARK CONTINENTAL OIL CO.



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LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

HAWKESBURY SANDSTONE 1

LINE H.S. 1 SP'S. 1407 - 1409

VELOCITY DISTRIBUTION	Vi = 12000 + ·6 z
WEATHERING VELOCITY (V_w)	3000 F/SEC.
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	10000 F/SEC.
WEATHERING METHOD	–
HORIZONTAL SCALE 1 : 2400'	DATUM M.S.L + 800'
TYPE OF PROFILING	TRANSPOSED
GEOPHONE INTERVAL	132'
OFFSET DISTANCE	4026' – 5214'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 10 - 40	No. OF SWEEPS 20
PLAYBACK FILTER	OUT - 42
MIXING	–

VIBRATOR PATTERN:

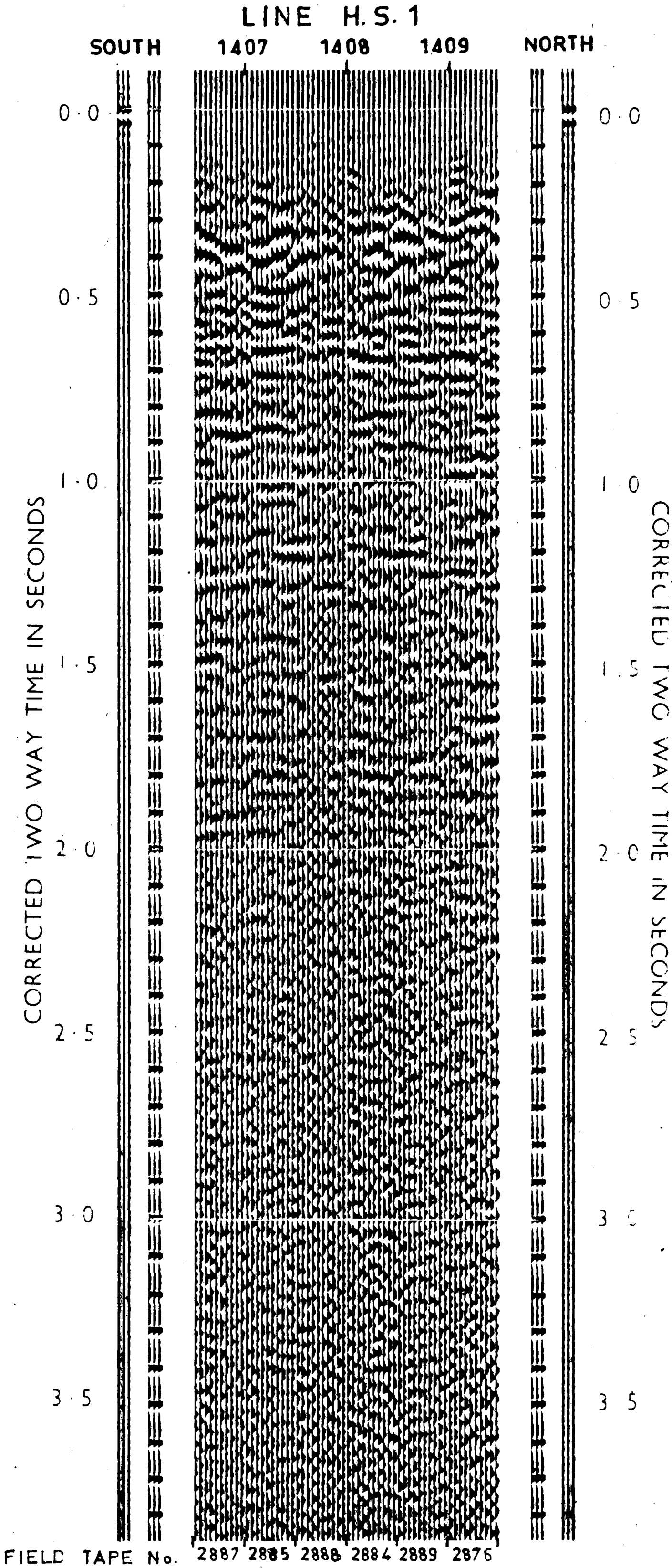
600' IN LINE

GEOPHONE PATTERN:

600' X 200' RECTANGLE OF 360 GEOPHONES

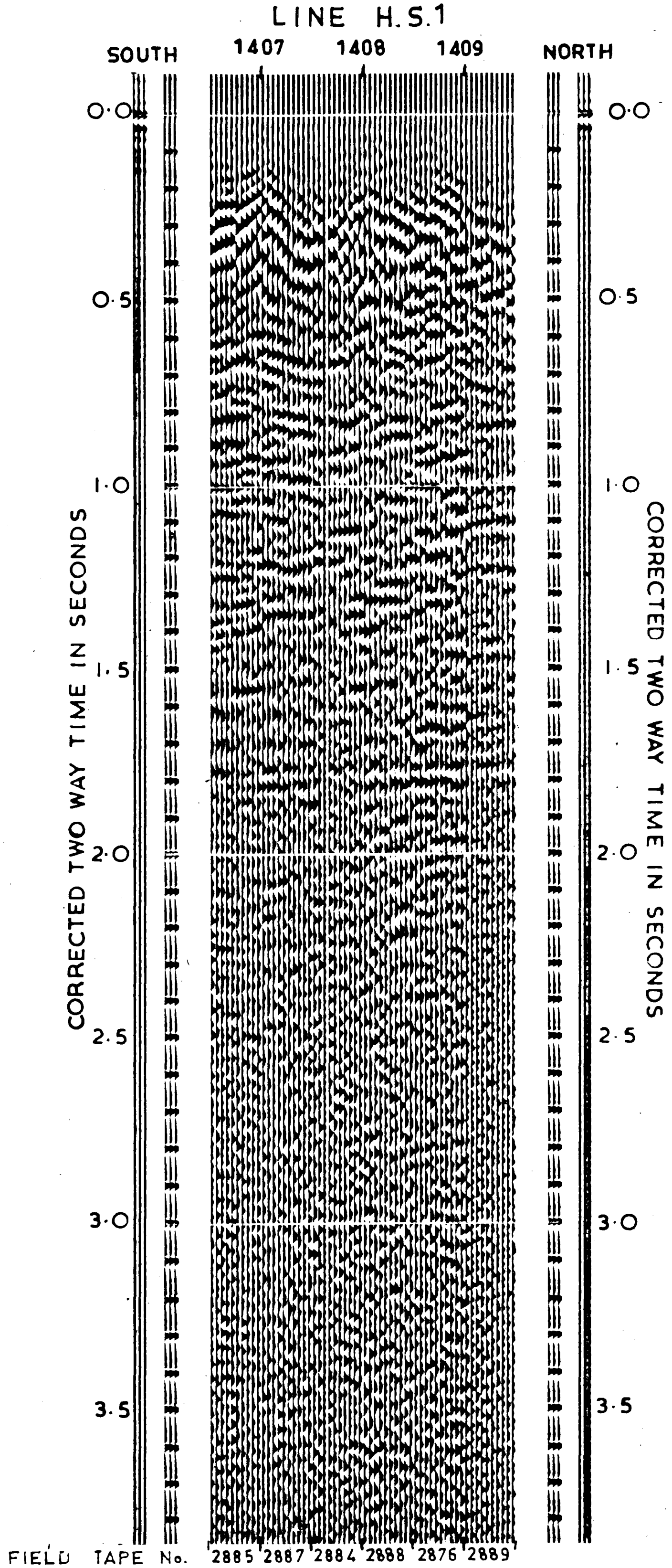
PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 62	FIELD AREA REPORT

®A TRADE MARK CONTINENTAL OIL CO.



SEISMOGRAPH SERVICE LIMITED LONDON ENGLAND	
VARIABLE AREA CROSS-SECTION VIBROSEIS● FOR BUREAU OF MINERAL RESOURCES	
HAWKESBURY SANDSTONE 1	
LINE H.S.1 SP'S. 1407 – 1409	
VELOCITY DISTRIBUTION	Vi = 12000 + ·6z
WEATHERING VELOCITY (Vw)	3000 F/SEC.
HORIZONTAL VELOCITY (Vh)	–
ELEVATION VELOCITY (Ve)	10000 F/SEC.
WEATHERING METHOD	–
HORIZONTAL SCALE 1:2400'	DATUM M.S.L. + 800'
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	132'
OFFSET DISTANCE	2706' – 3894'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 10 – 40	No. OF SWEEPS 20
PLAYBACK FILTER	OUT – 42
MIXING	–
VIBRATOR PATTERN: 1000' IN LINE	
GEOPHONE PATTERN: 1000' X 200' RECTANGLE OF 360 GEOPHONES	
PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 63	FIELD AREA REPORT

●A TRADE MARK CONTINENTAL OIL CO.



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LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

HAWKESBURY SANDSTONE 1

LINE H.S. 1 SP'S. 1407 – 1409

VELOCITY DISTRIBUTION	Vi = 12000 + ·6z
WEATHERING VELOCITY (Vw)	3000 F/SEC.
HORIZONTAL VELOCITY (Vh)	–
ELEVATION VELOCITY (Ve)	10000 F/SEC.
WEATHERING METHOD	–
HORIZONTAL SCALE 1" : 2400'	DATUM M.S.L. + 800'
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	132'
OFFSET DISTANCE	4026' – 5214'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 10 – 40	No. OF SWEEPS 20
PLAYBACK FILTER	OUT – 42
MIXING	–

VIBRATOR PATTERN:

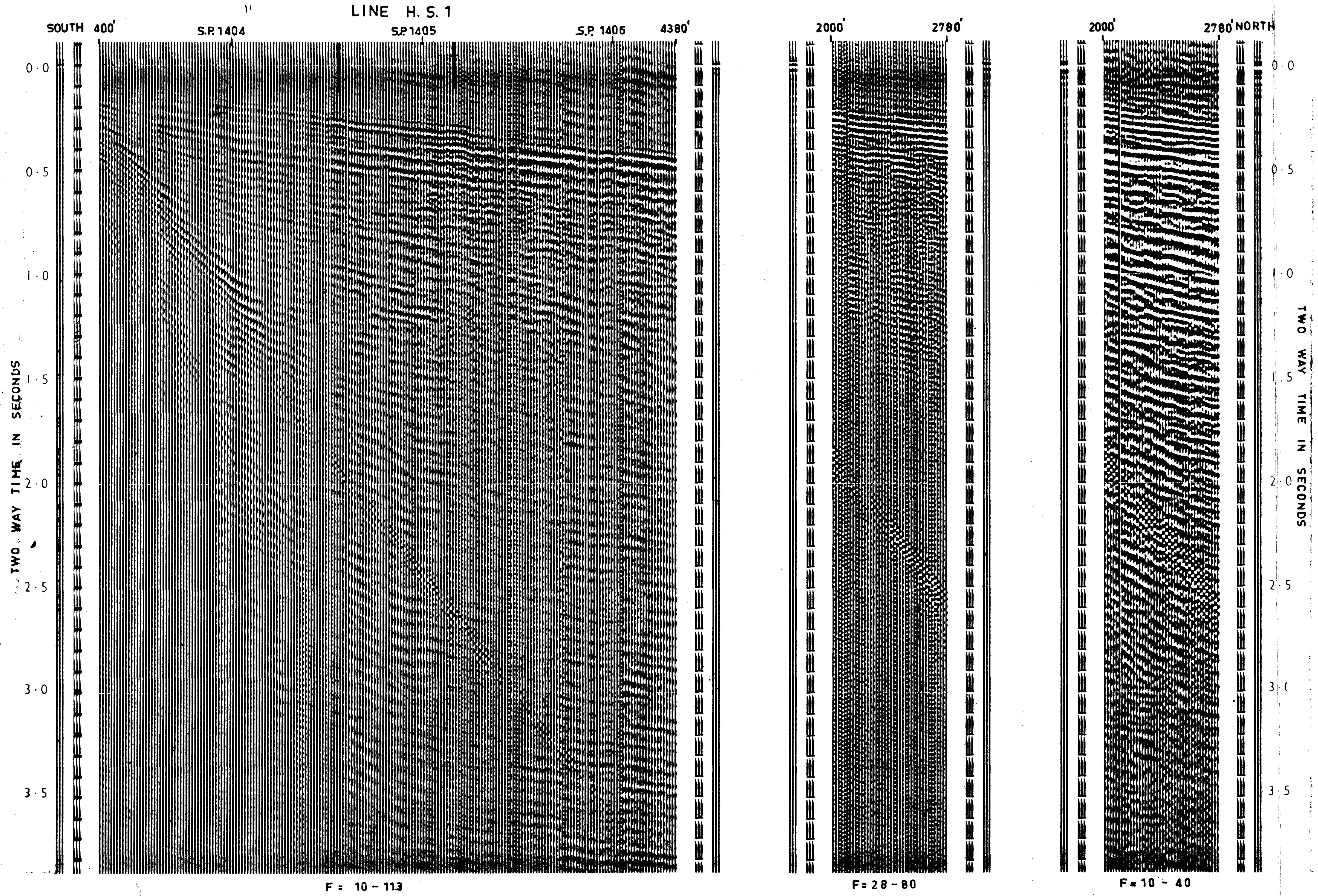
1000' IN LINE

GEOPHONE PATTERN:

1000' X 200' RECTANGLE OF 360 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 64	FIELD AREA REPORT

® A TRADE MARK CONTINENTAL OIL CO.



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS*
FOR BUREAU OF MINERAL RESOURCES

HAWKESBURY SANDSTONE 1

LINE H.S.1 SP'S. NOISE SPREAD

VELOCITY DISTRIBUTION	-		
WEATHERING VELOCITY (V_w)	-		
HORIZONTAL VELOCITY (V_h)	-		
ELEVATION VELOCITY (V_e)	-		
WEATHERING METHOD	-		
HORIZONTAL SCALE	-	DATUM	-
TYPE OF PROFILING	IN LINE		
GEOPHONE INTERVAL	20'		
OFFSET DISTANCE	400' - 4380'		
No. AND TYPE OF VIBRATORS	1		
SWEEP FREQUENCY S.B.S.	No. OF SWEEPS 1-10		
PLAYBACK FILTER	OUT		
MIXING	–		

VIBRATOR PATTERN:

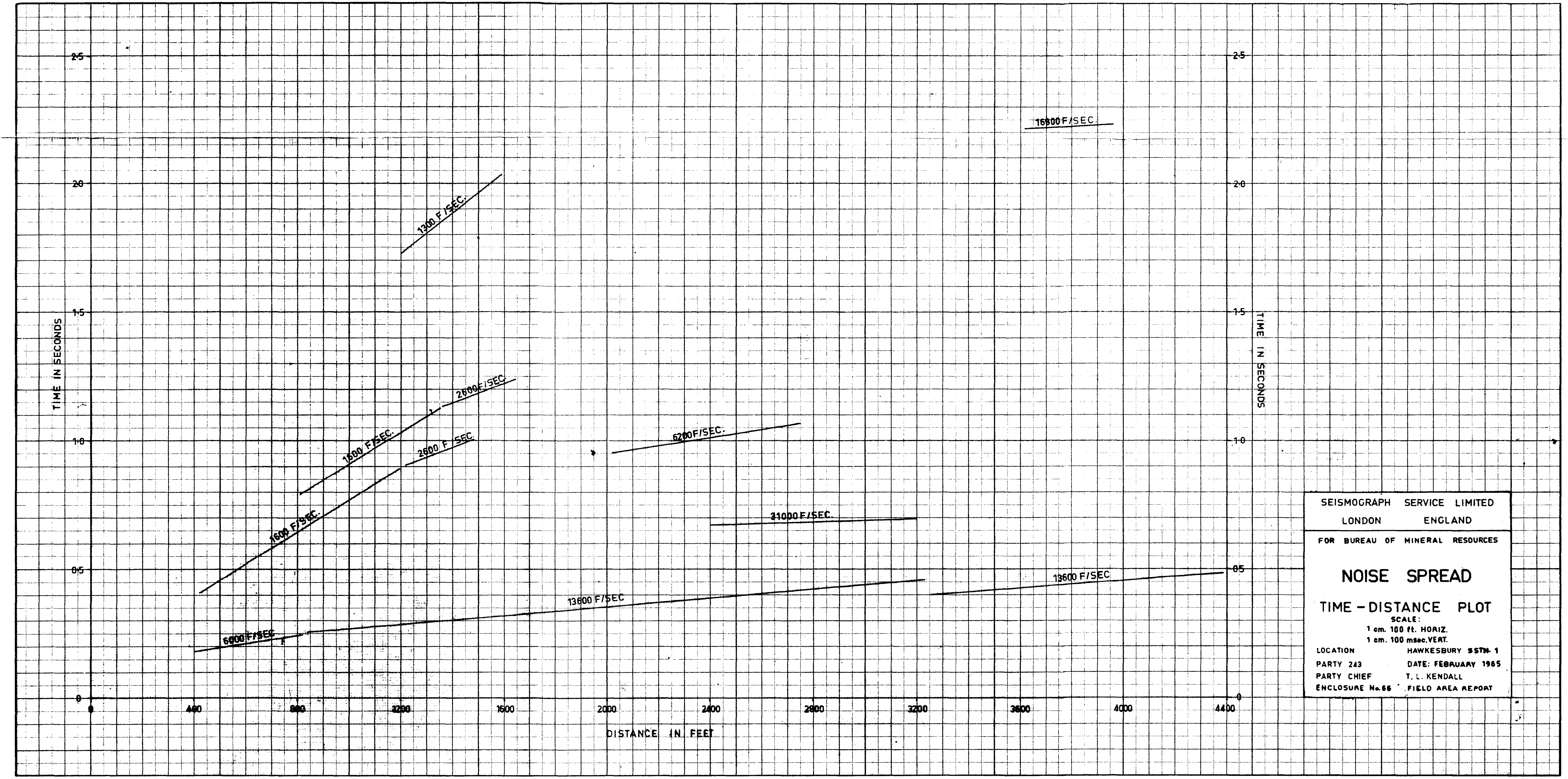
ZERO

GEOPHONE PATTERN:

10 GEOPHONES AT RIGHT ANGLES TO LINE

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 65	FIELD AREA REPORT

*A TRADE MARK CONTINENTAL OIL CO.



TIME IN SECONDS
2·5
2·0
1·5
1·0
0·5
0
0
400
800
1600
2000
2400
2800
3200
3600
4000
4400
DISTANCE IN FEET
1300 F/SEC.
2600 F/SEC.
1600 F/SEC.
2600 F/SEC.
1600 F/SEC.
6200 F/SEC.
31000 F/SEC.
13600 F/SEC
13600 F/SEC
6600 F/SEC
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
NOISE SPREAD
TIME - DISTANCE PLOT
SCALE:
1 cm. 100 ft. HORIZ.
1 cm. 100 msec. VERT.
LOCATION HAWKESBURY SSTN 1
PARTY 243 DATE: FEBRUARY 1965
PARTY CHIEF T. L. KENDALL
ENCLOSURE No. 66 FIELD AREA REPORT

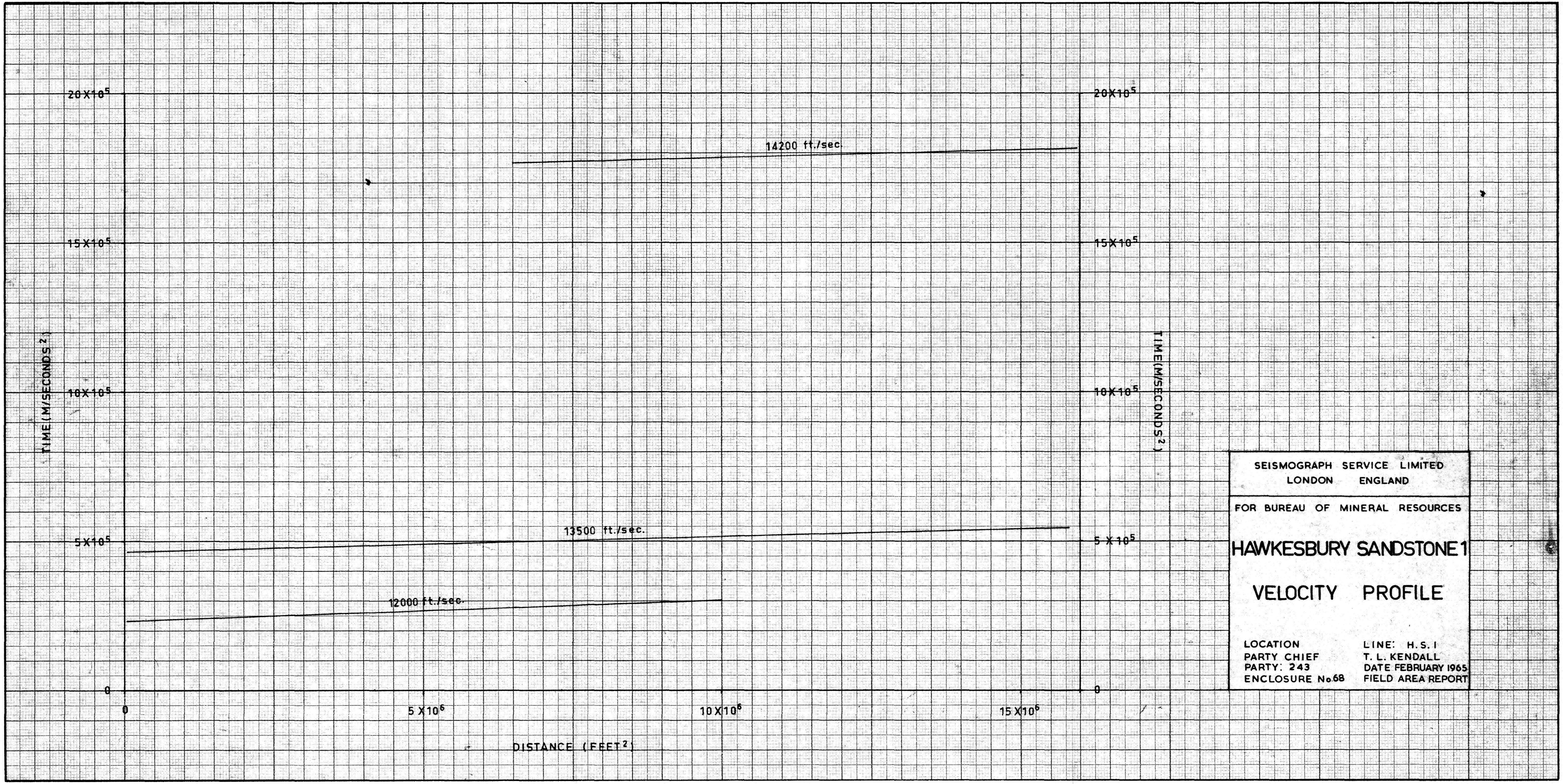
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

NOISE SPREAD

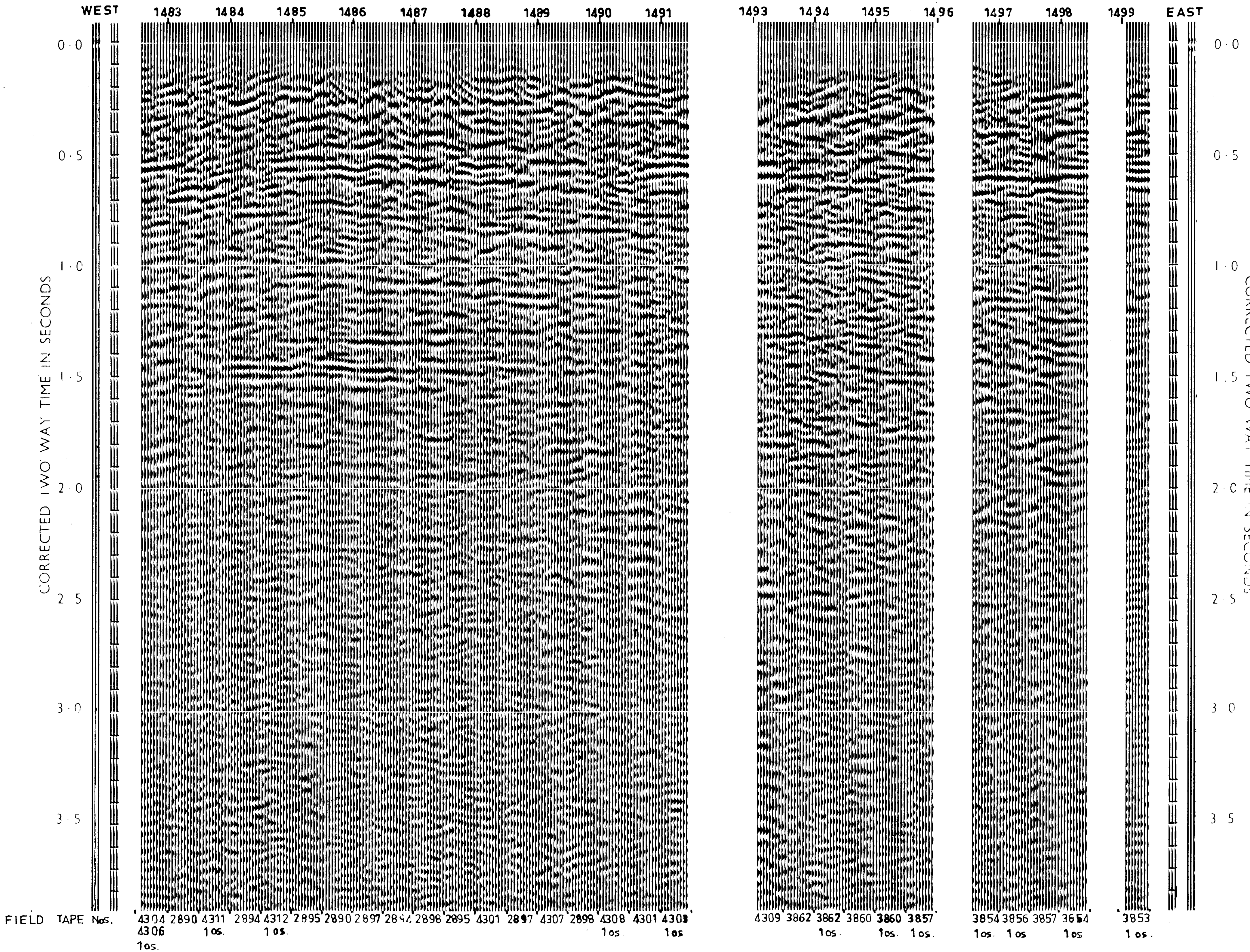
FREQUENCY-WAVE No.PLOT
RESPONSE - WAVE No PLOT
RESPONSE-FREQUENCY PLOT

LOCATION	HAWKESBURY SSTN.1
PARTY 243	DATE AUGUST-1964
PARTY CHIEF	T. L. KENDALL
ENCLOSURE No.67	FIELD AREA REPORT



20X10^5
15X10^5
10X10^5
5X10^5
0
TIME (M/SECONDS²)
14200 ft./sec.
13500 ft./sec.
12000 ft./sec.
0
5X10^6
10X10^6
15X10^6
DISTANCE (FEET²)
TIME(M/SECONDS²)
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
HAWKESBURY SANDSTONE 1
VELOCITY PROFILE
LOCATION
LINE: H.S.I
PARTY CHIEF
T. L. KENDALL
PARTY: 243
DATE FEBRUARY 1965
ENCLOSURE No.68
FIELD AREA REPORT

LINE H.S. 2



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LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS*
FOR BUREAU OF MINERAL RESOURCES

HAWKESBURY SANDSTONE 2

LINE H.S. 2 SP'S. 1483 - 1499

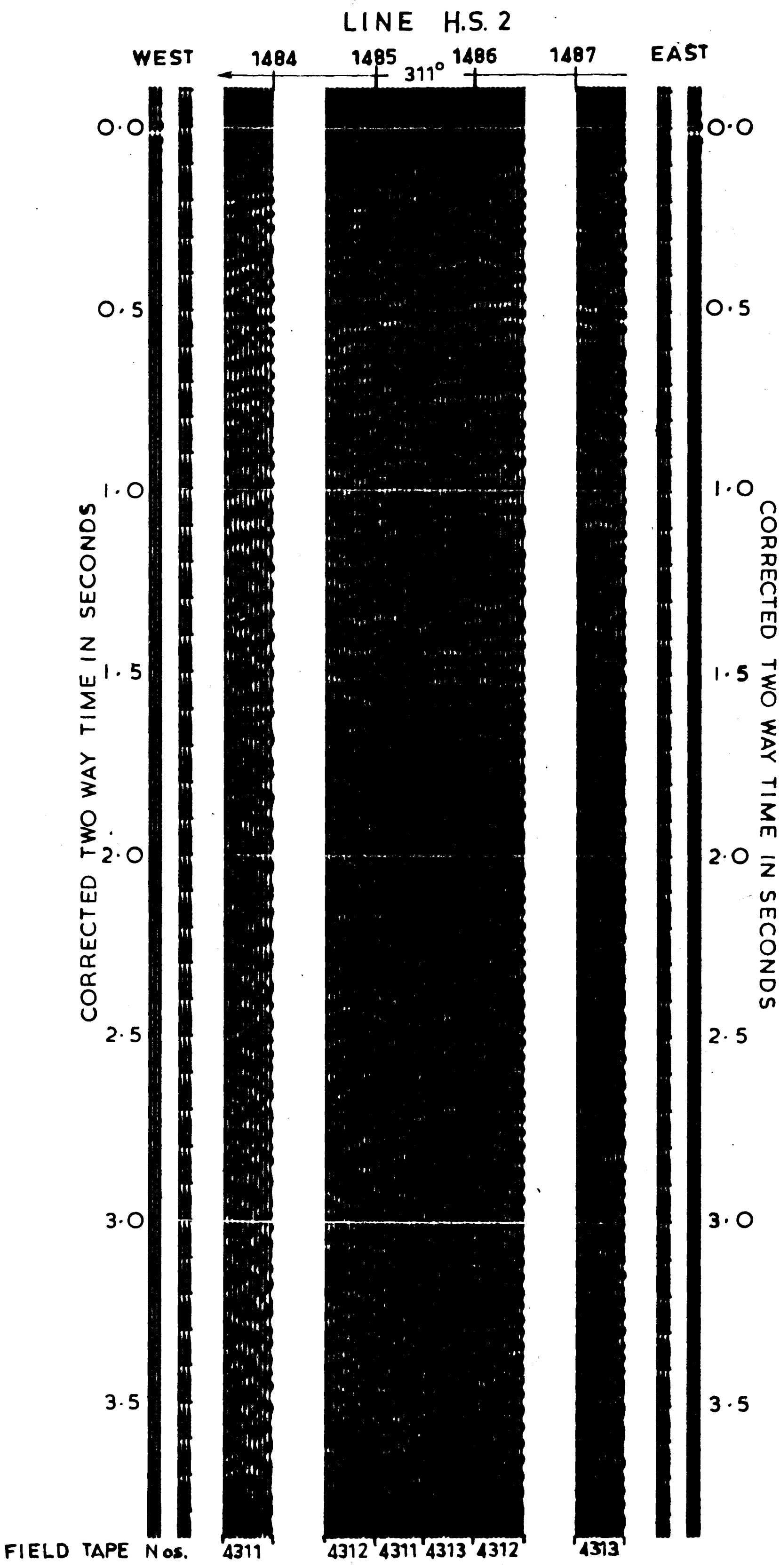
VELOCITY DISTRIBUTION	Vi = 12000 + ·6z
WEATHERING VELOCITY (V_w)	3000 F/SEC.
HORIZONTAL VELOCITY (V_h)	-
ELEVATION VELOCITY (V_e)	10000 F/SEC
WEATHERING METHOD	-
HORIZONTAL SCALE 1" : 2400'	DATUM M.S.L. + 800'
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	132'
OFFSET DISTANCE	1386'-2574' & 2706'-3894'
No. AND TYPE OF VIBRATORS	2 & 3
SWEEP FREQUENCY 10 - 40	No. OF SWEEPS 10-20
PLAYBACK FILTER	OUT - 42
MIXING	3/2 COMPOSITED

VIBRATOR PATTERN:
1000' IN LINE

GEOPHONE PATTERN:
1000' X 200' RECTANGLE OF 360 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 69	FIELD AREA REPORT

*A TRADE MARK CONTINENTAL OIL CO.



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LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

HAWKESBURY SANDSTONE 2

LINE H. S. 2	SP.'S. 1484 – 1487		
VELOCITY DISTRIBUTION	Vi = 12000 + ·6z		
WEATHERING VELOCITY (Vw)	3000 F/SEC.		
HORIZONTAL VELOCITY (Vh)	–		
ELEVATION VELOCITY (Ve)	10000 F/SEC.		
WEATHERING METHOD	–		
HORIZONTAL SCALE 1": 2400'		DATUM	M.S.L + 800
TYPE OF PROFILING	TRANSPOSED		
TRACE INTERVAL	132'		
OFFSET DISTANCE	1386' – 2574'		
No. AND TYPE OF VIBRATORS	3		
SWEEP FREQUENCY 10 – 40		No. OF SWEEPS	10:20
PLAYBACK FILTER	OUT – 42		
MIXING	–		

VIBRATOR PATTERN:

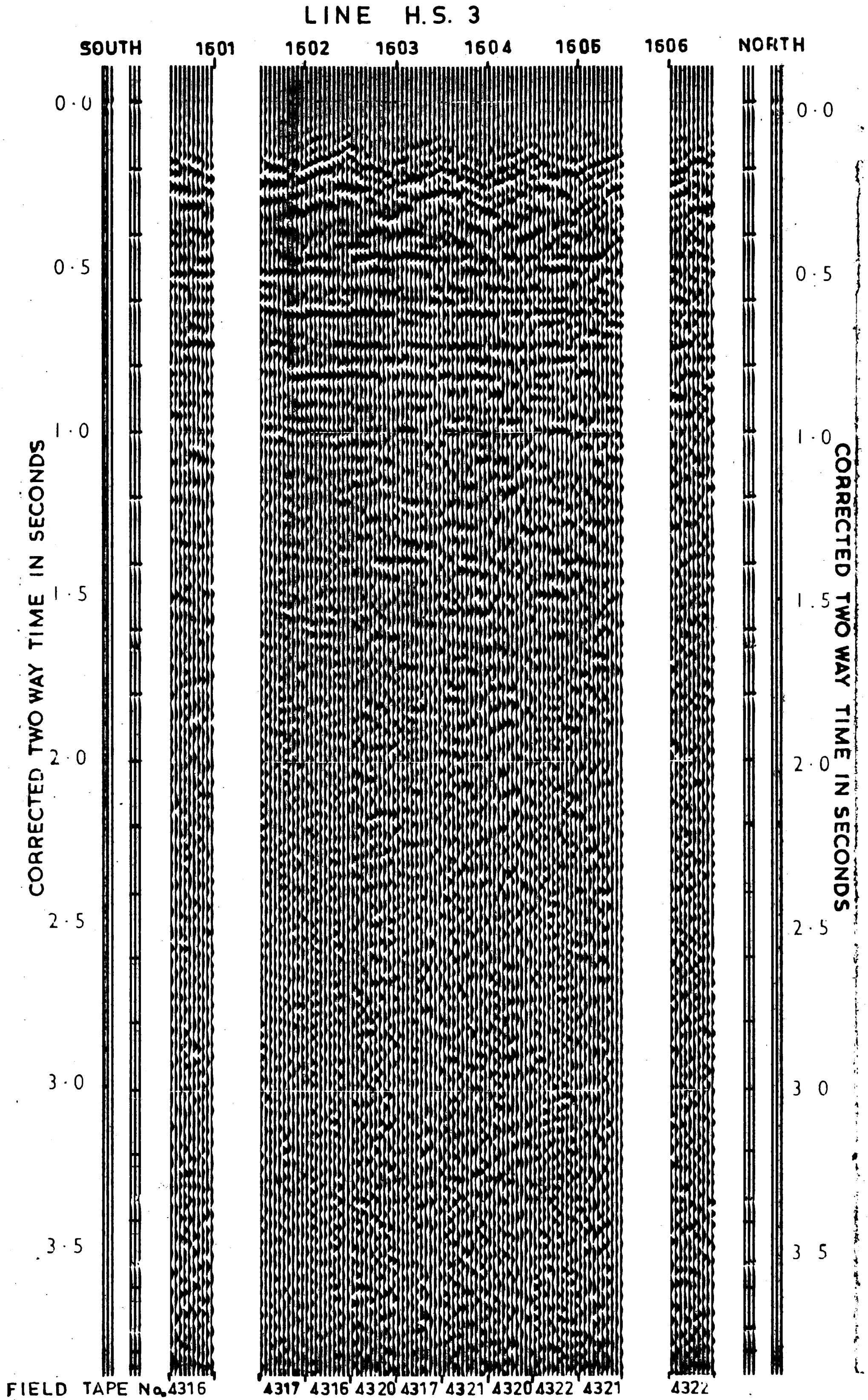
1000' IN LINE

GEOPHONE PATTERN:

1000' X 200' RECTANGLE OF 360 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 70	FIELD AREA REPORT

®A TRADE MARK CONTINENTAL OIL CO.



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LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

HAWKESBURY SANDSTONE 3

LINE H.S. 3 SP'S. 1601 – 1606

VELOCITY DISTRIBUTION	Vi = 12000 + 6z
WEATHERING VELOCITY (V_w)	3000 F/SEC.
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	10000 F/SEC.
WEATHERING METHOD	–
HORIZONTAL SCALE 1" : 2400'	DATUM M.S.L+1000'
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	132'
OFFSET DISTANCE	1386' – 2574'
No. AND TYPE OF VIBRATORS	2 & 3
SWEEP FREQUENCY 10 – 40	No. OF SWEEPS 10
PLAYBACK FILTER	OUT-42
MIXING	–

VIBRATOR PATTERN:

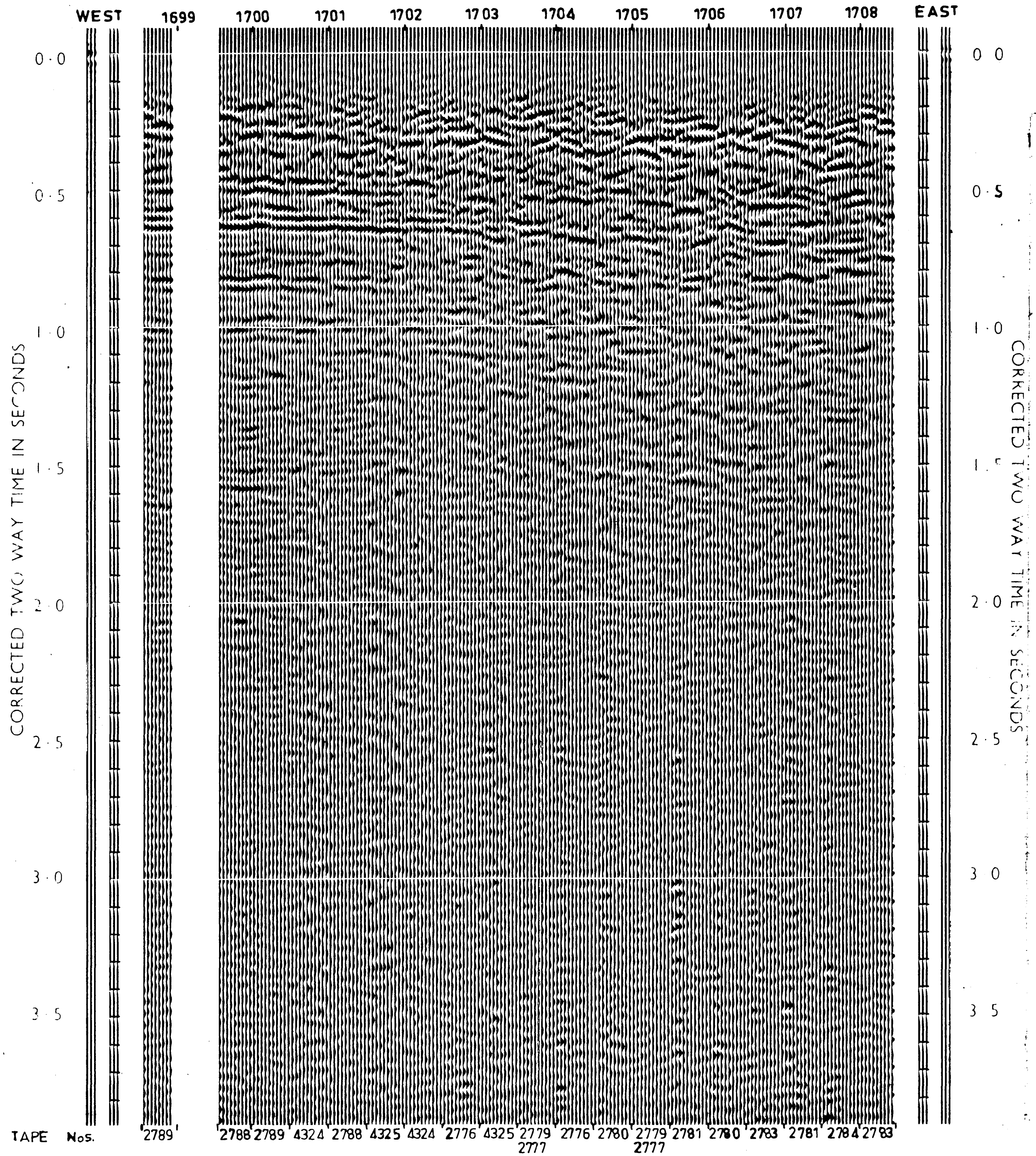
600' IN LINE

GEOPHONE PATTERN:

600' X 200' RECTANGLE OF 360 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 71	FIELD AREA REPORT

LINE H.S.4



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LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS*
FOR BUREAU OF MINERAL RESOURCES

HAWKESBURY SANDSTONE 4

LINE H.S.4 SP'S. 1699 – 1708

VELOCITY DISTRIBUTION	Vi = 12000 + ·6 z
WEATHERING VELOCITY (V_w)	3000 F/SEC.
HORIZONTAL VELOCITY (V_h)	–
ELEVATION VELOCITY (V_e)	10000 F/SEC
WEATHERING METHOD	–
HORIZONTAL SCALE 1" : 2400'	DATUM MSL + 1000
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	132'
OFFSET DISTANCE	1386' – 2574'
No. AND TYPE OF VIBRATORS	2 & 3
SWEEP FREQUENCY 10 – 40	No. OF SWEEPS 10; 20
PLAYBACK FILTER	OUT-42
MIXING	3/2 COMPOSITED

VIBRATOR PATTERN:

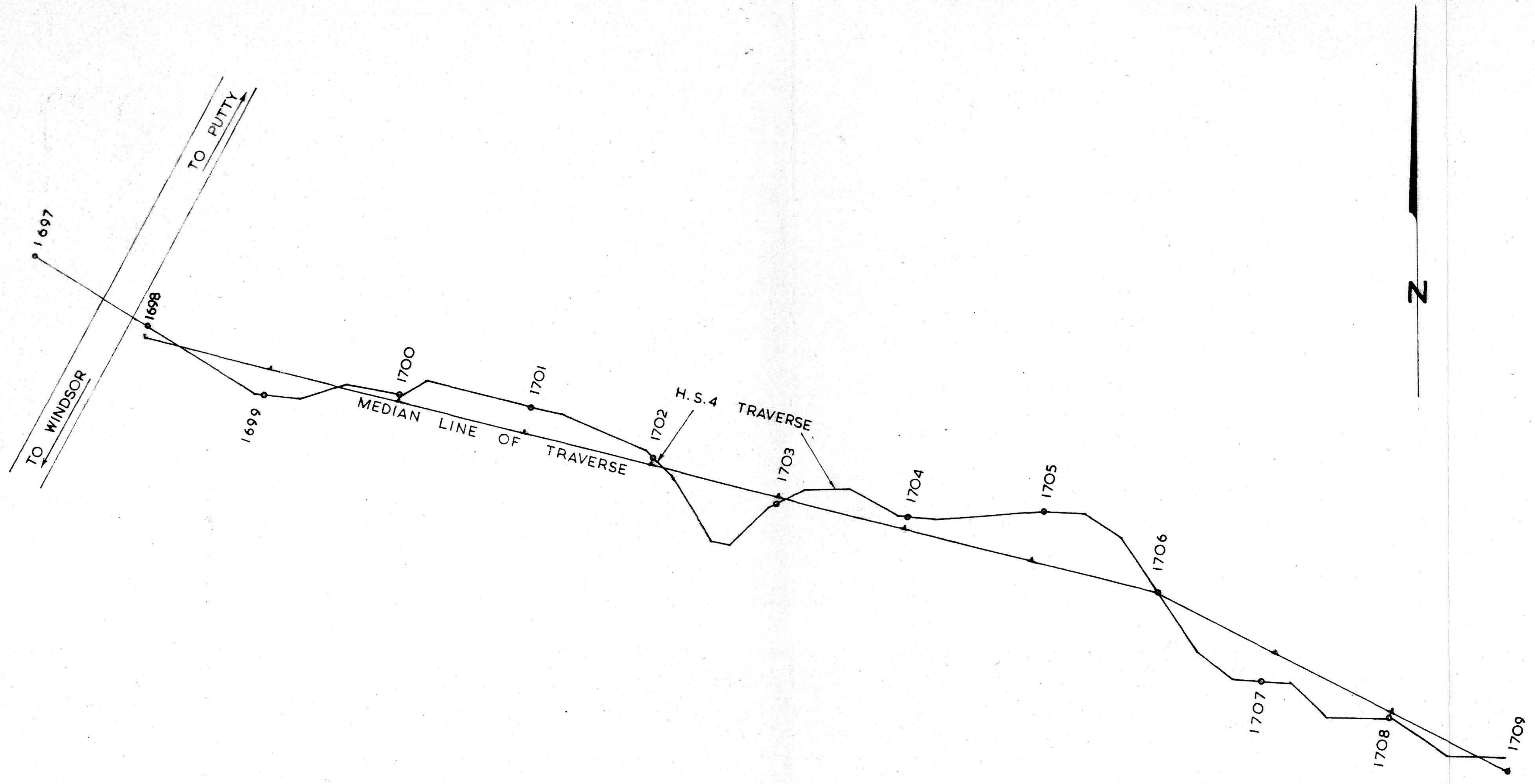
600' IN LINE

GEOPHONE PATTERN:

600' X 200' RECTANGLE OF 360 GEOPHONES

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 72	FIELD AREA REPORT

*A TRADE MARK CONTINENTAL OIL CO.



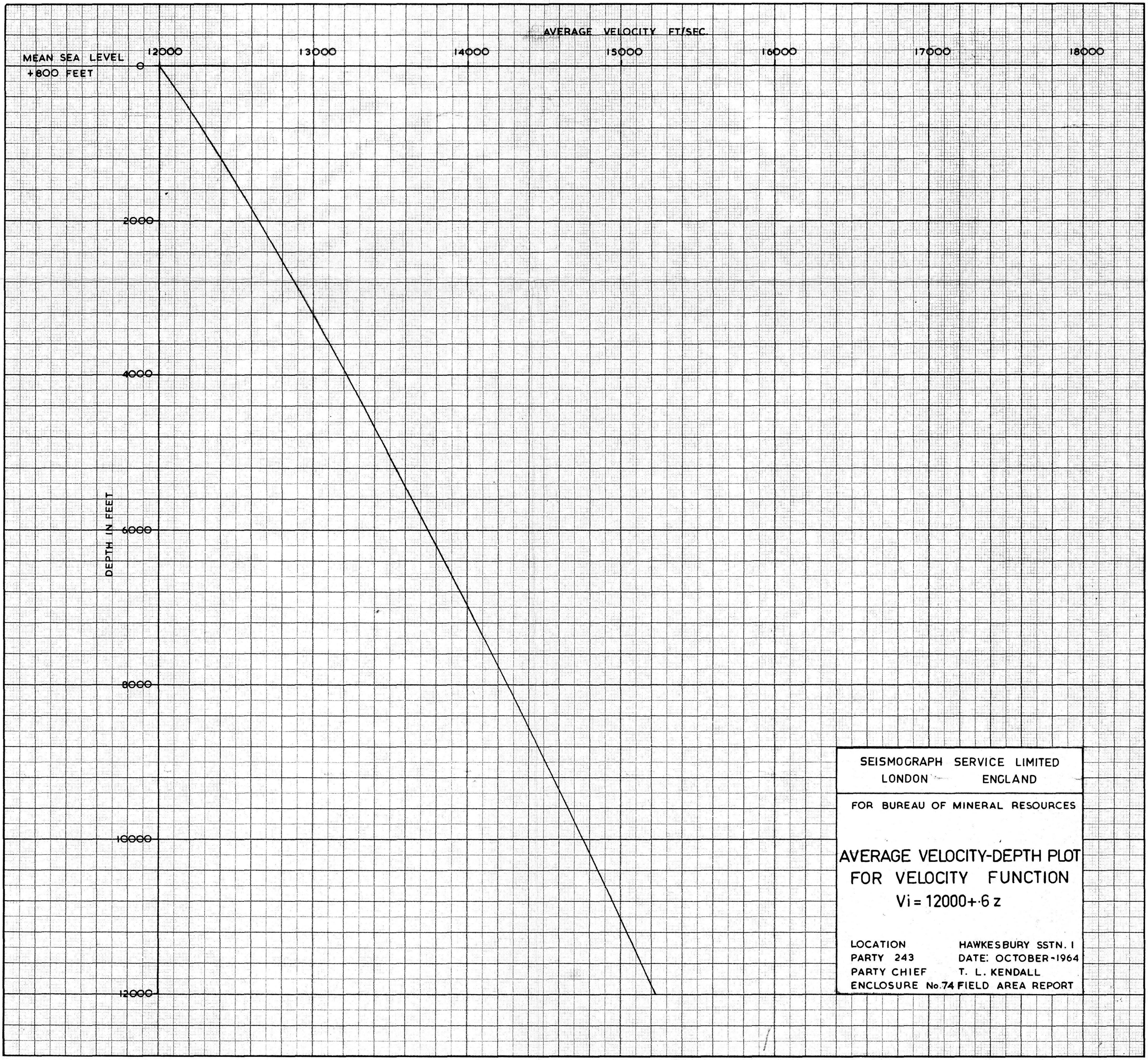
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

HAWKESBURY SANDSTONE 4

MAP OF TRAVERSE

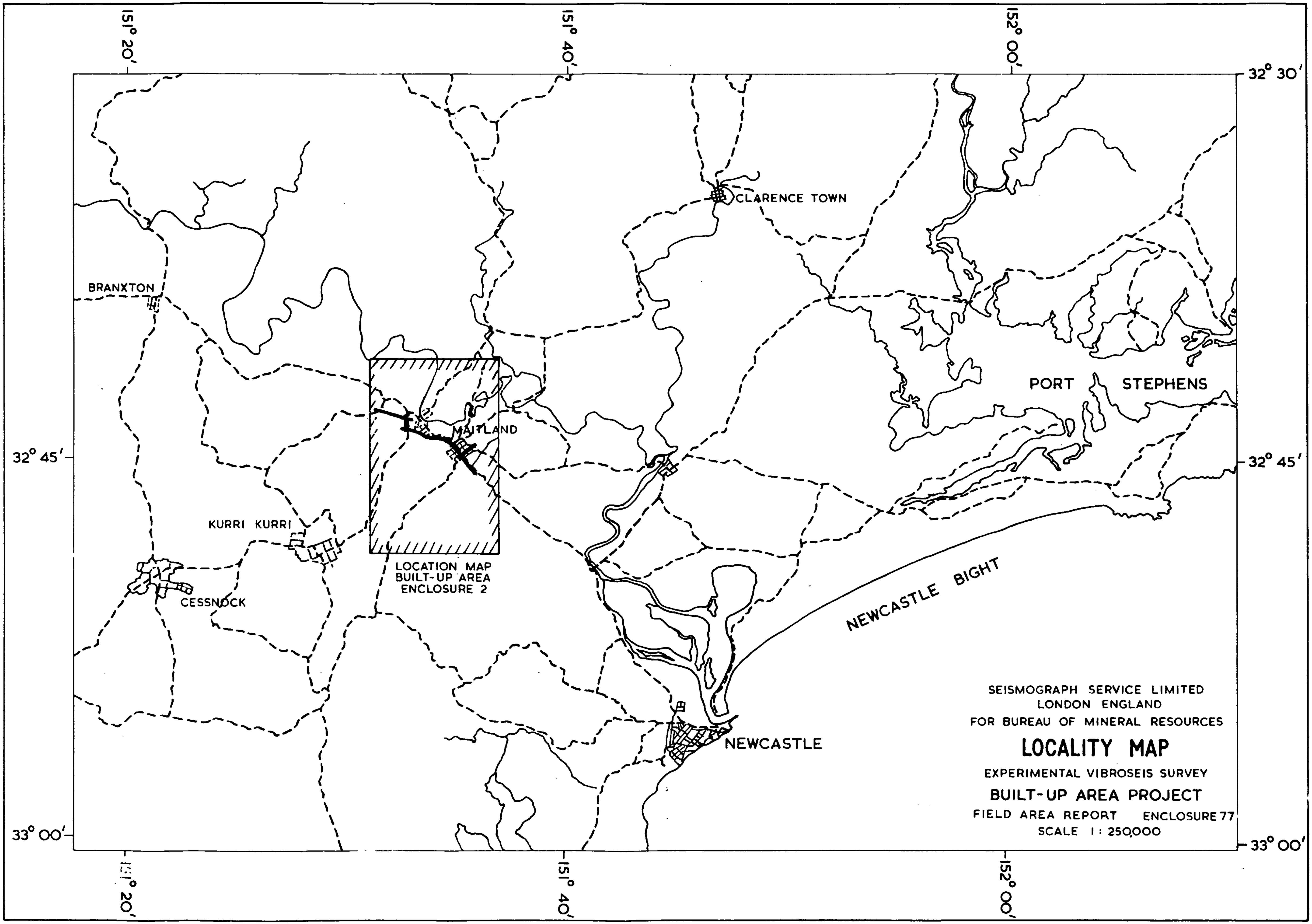
APROX. SCALE 4 INS. TO 1 MILE
PARTY CHIEF T. L. KENDALL
PARTY 243 DATE: FEBRUARY 1965
ENCLOSURE No. 73 FIELD AREA REPORT

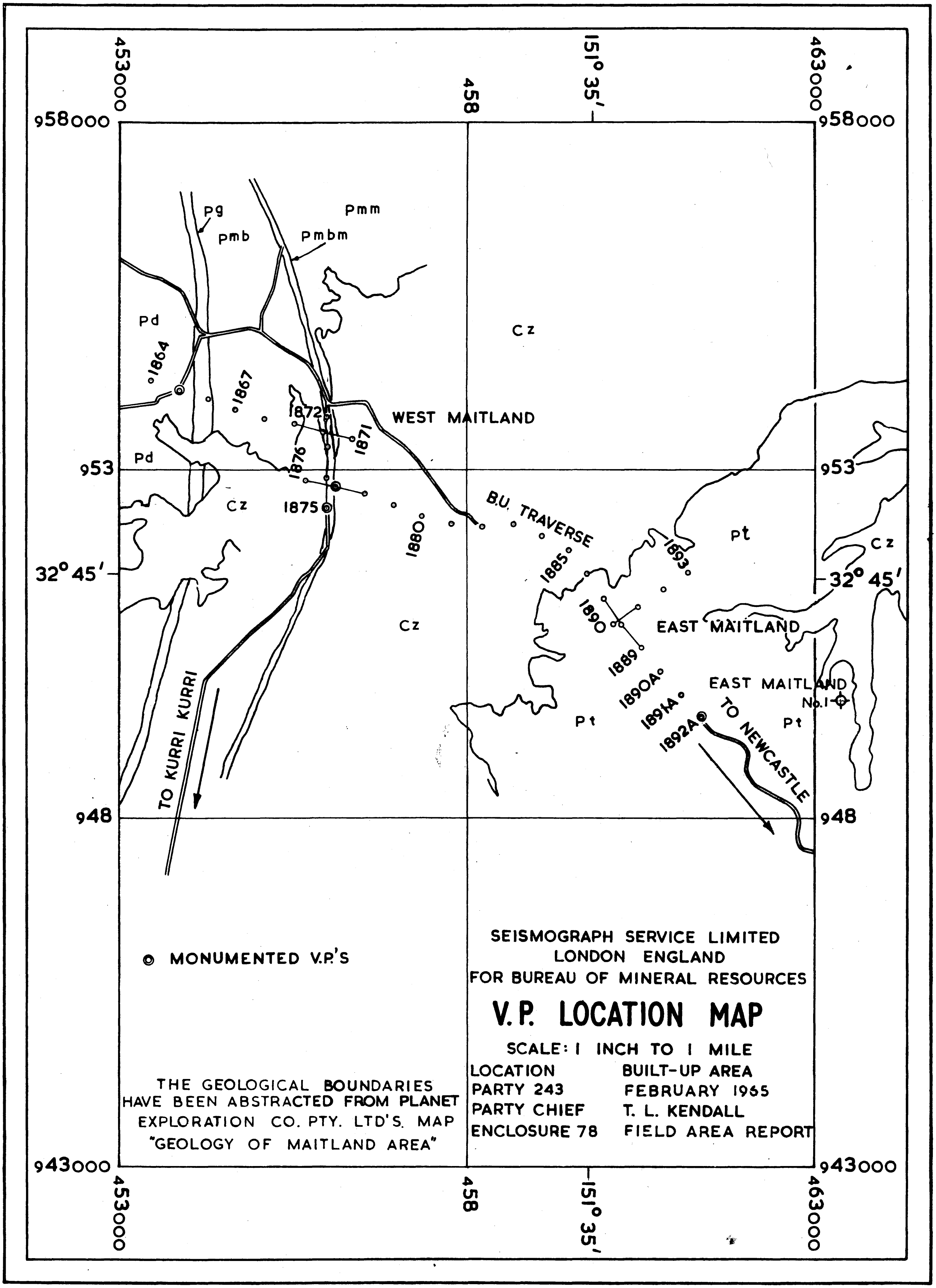


AVERAGE VELOCITY FT/SEC.
MEAN SEA LEVEL
+800 FEET
12000
13000
14000
15000
16000
17000
18000
0
2000
4000
6000
8000
10000
12000
DEPTH IN FEET
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
AVERAGE VELOCITY-DEPTH PLOT
FOR VELOCITY FUNCTION
Vi = 12000+·6 z
LOCATION HAWKESBURY SSTN. I
PARTY 243 DATE: OCTOBER-1964
PARTY CHIEF T. L. KENDALL
ENCLOSURE No.74 FIELD AREA REPORT

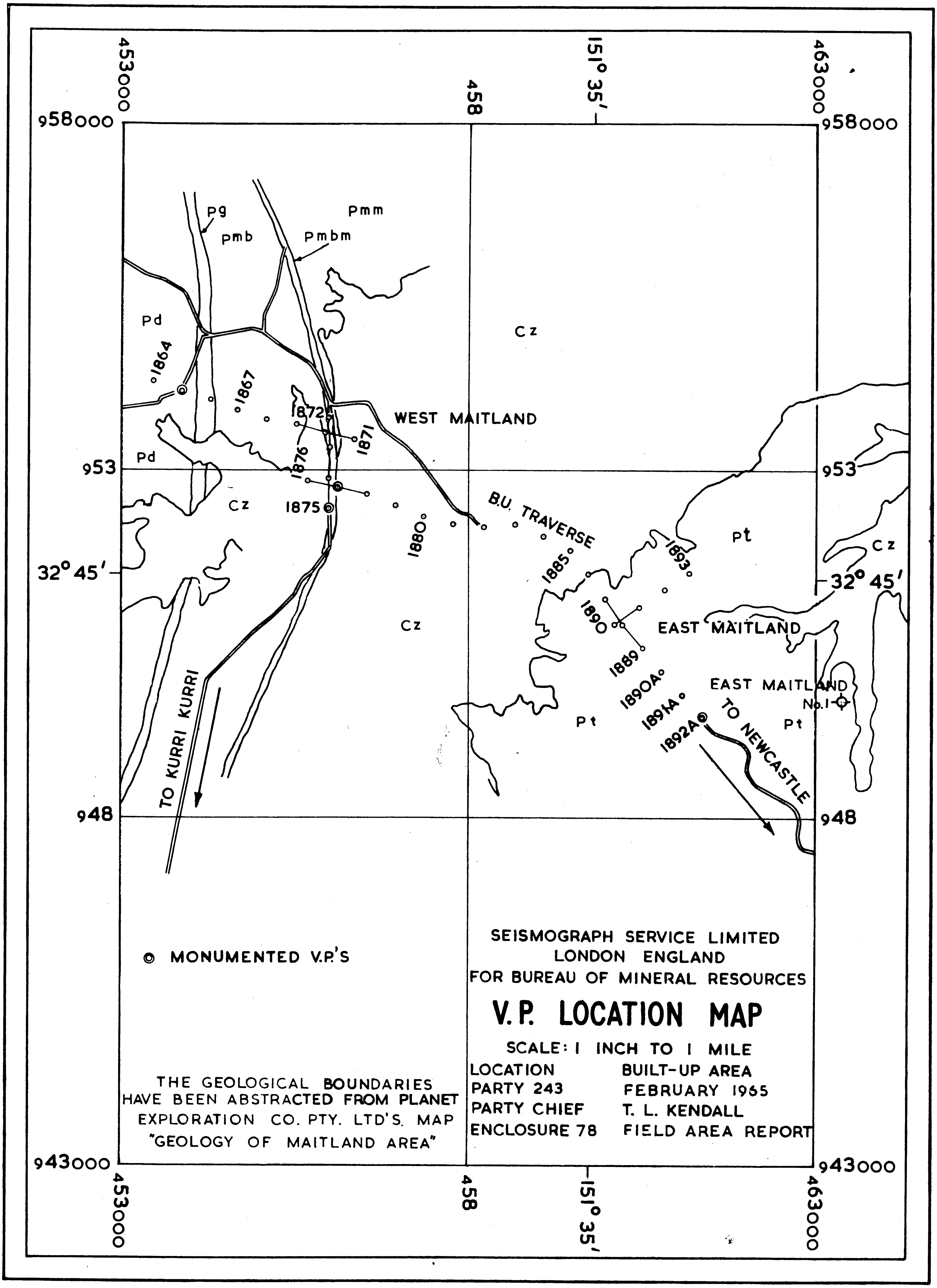
1402 1403 1404 1405 1406 1407 1408 1409 1410 1411 1412 1413 1414 1415
25 AUGUST
26 AUGUST
27 AUGUST
28 AUGUST
31 AUGUST
1 SEPTEMBER
2 SEPTEMBER
5 SEPTEMBER
7 SEPTEMBER
8 SEPTEMBER
9 SEPTEMBER
10 SEPTEMBER
11 SEPTEMBER
LEGEND:
① FIELD TAPE No. 5216 etc.
② No OF GEOPHONES A = 360
③ No OF SWEEPS 1 OS : 2 OS etc.
④ VIB PATTERN 400 : 600 etc.
⑤ SWEEP FREQUENCY X 10-40 : Y 20-57 : Z 14-40
⑥ OFFSET DISTANCE 1 OS 2 OS etc.
⑦ GEOPHONE PATTERN SHAPE
①:②:③:④
⑤:⑥:⑦
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
SCHEMATIC DIAGRAM
TO SHOW SUB-SURFACE
PROFILES FOR THE
HAWKESBURY SANDSTONE 1.
PROJECT
PARTY: 243
PARTY CHIEF
ENCLOSURE No. 75
DATE: FEBRUARY 1965
T. L. KENDALL
FIELD AREA REPORT

LEGEND:
① FIELD TAPE No. 3862 etc.
② No. OF GEOPHONES A=40 B=360
③ No. OF SWEEPS 10 S, 20 S etc.
④ VIB. PATTERN 400, 600 etc.
⑤ SWEEP FREQUENCY X=10-40
⑥ OFFSET DISTANCE 1 OS, 2 OS
⑦ GEOPHONE PATTERN SHAPE
①:②:③:④
⑤:⑥:⑦
1481 1482 1483 1484 1485 1486 1487 1488 1489 1490 1491 1492 1493 1494 1495 1496 1497 1498 1499 1500
3 SEPTEMBER
4 SEPTEMBER
14 SEPTEMBER
15 SEPTEMBER
16 SEPTEMBER
17 SEPTEMBER
18 SEPTEMBER
19 SEPTEMBER
(5 TRACES EACH DAY)
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
SCHEMATIC DIAGRAM
TO SHOW SUB-SURFACE
PROFILES FOR THE
HAWKESBURY SANDSTONE 2.
PROJECT
PARTY 243
PARTY CHIEF
ENCLOSURE No.76
FEBRUARY 1965
T. L. KENDALL
FIELD AREA REPORT


151° 20′
151° 40′
152° 00′
32° 30′
32° 45′
33° 00′
CLARENCE TOWN
BRANXTON
PORT STEPHENS
MAITLAND
KURRI KURRI
CESSNOCK
LOCATION MAP
BUILT-UP AREA
ENCLOSURE 2
NEWCASTLE BIGHT
NEWCASTLE
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND
FOR BUREAU OF MINERAL RESOURCES
LOCALITY MAP
EXPERIMENTAL VIBROSEIS SURVEY
BUILT-UP AREA PROJECT
FIELD AREA REPORT ENCLOSURE 77
SCALE 1 : 250,000

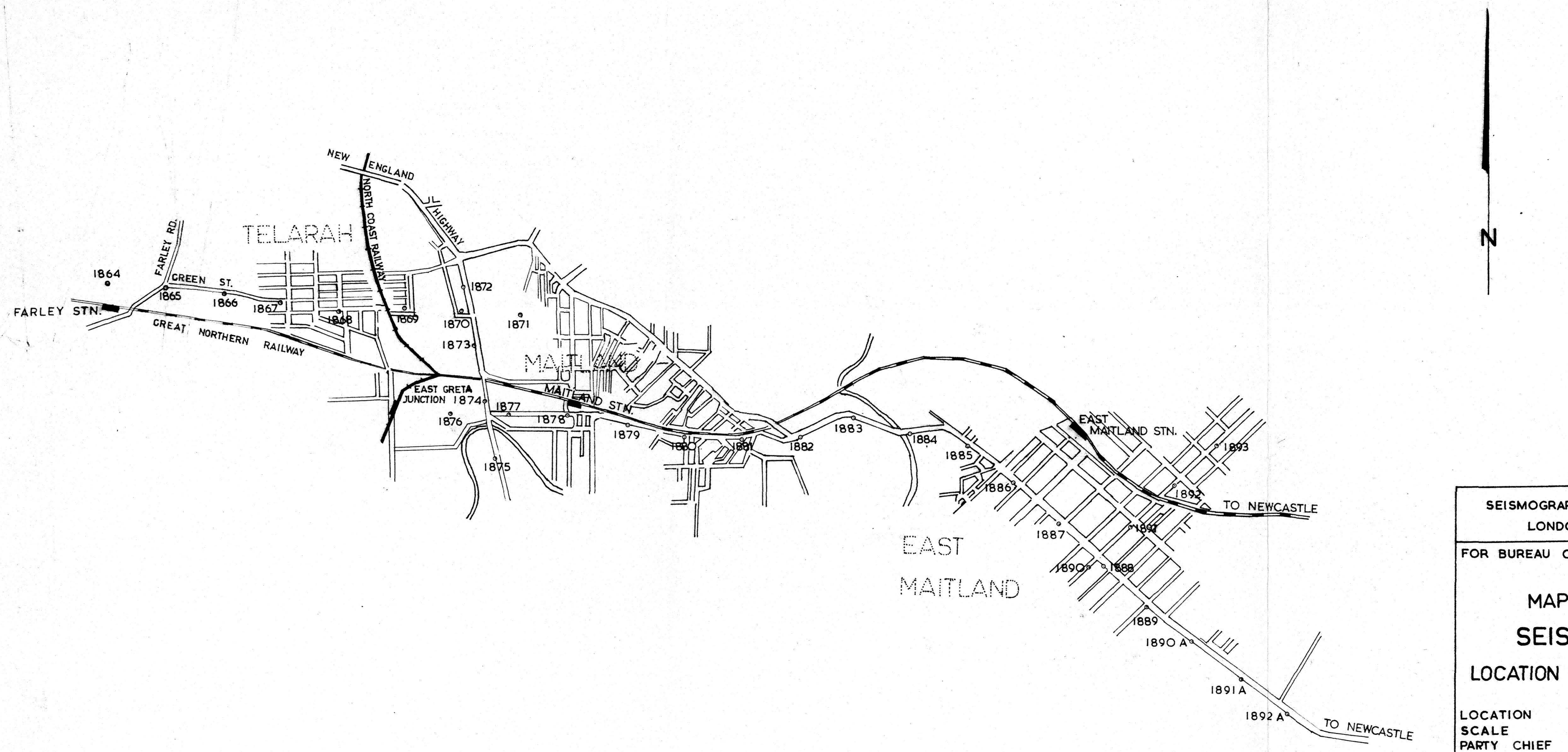


Pt	TOMAGO COAL MEASURES
Pmm	MULBRING SILTSTONE
Pmbm	BRANXTON FORMATION
Cz	RIVER ALLUVIUM
Pg	GRETA COAL MEASURES
Pd	DALWOOD GROUP



Pt TOMAGO COAL MEASURES | Pmm MULBRING SILTSTONE | Pmbm BRANXTON FORMATION

Cz RIVER ALLUVIUM | Pg GRETA COAL MEASURES | Pd DALWOOD GROUP



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

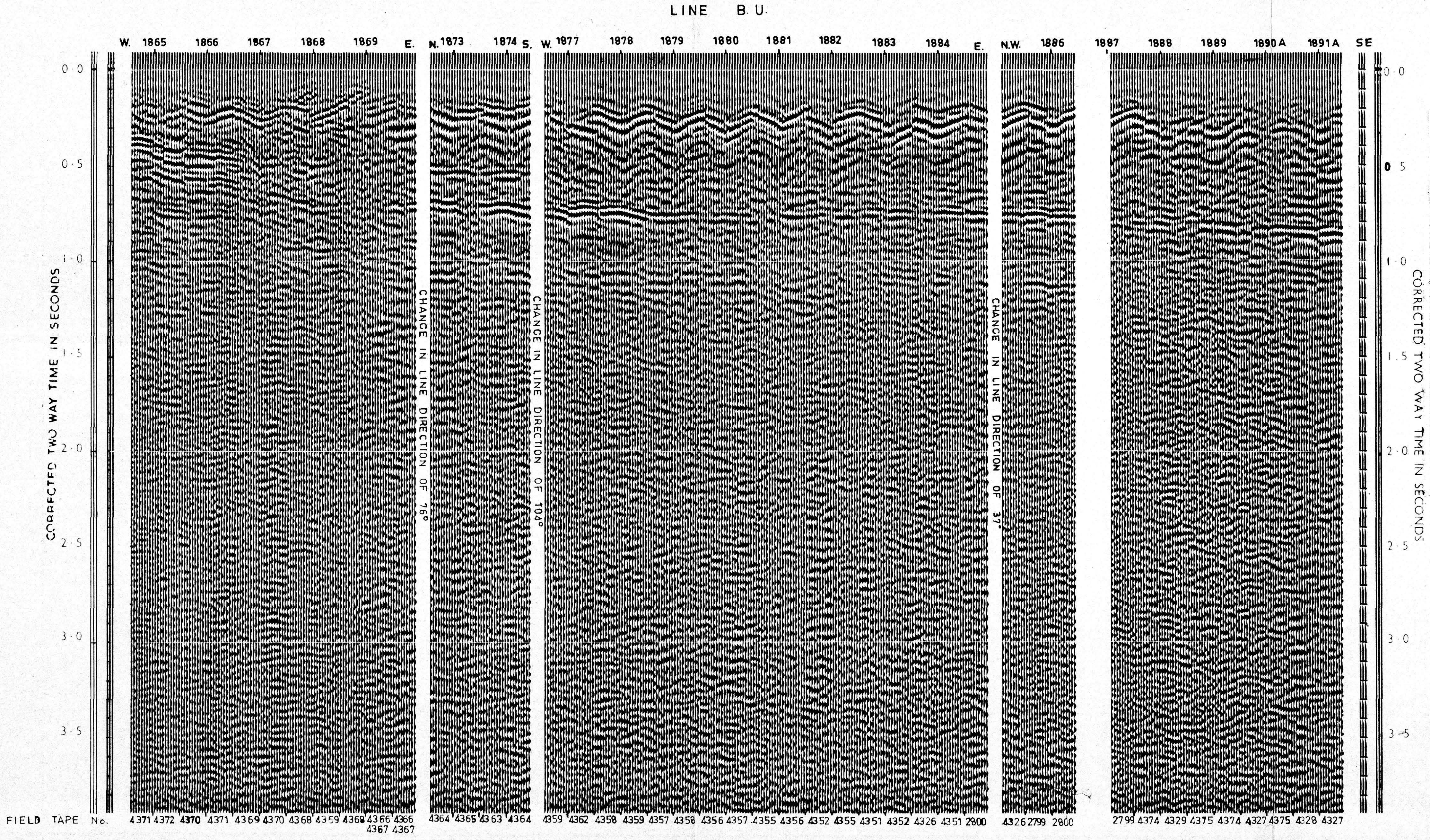
FOR BUREAU OF MINERAL RESOURCES

MAP SHOWING

SEISMIC LINE

LOCATION IN BUILT-UP AREA

LOCATION	MAITLAND
SCALE	2·5 INCHES TO 1 MILE
PARTY CHIEF	T. L. KENDALL
PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No.79	FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

VARIABLE AREA CROSS-SECTION
VIBROSEIS®
FOR BUREAU OF MINERAL RESOURCES

BUILT-UP AREA

LINE B.U.	S.P'S. 1865-1891A
VELOCITY DISTRIBUTION	Vi= 12000+ 6z
WEATHERING VELOCITY (V_w)	-
HORIZONTAL VELOCITY (V_h)	-
ELEVATION VELOCITY (V_e)	10000 F/SEC.
WEATHERING METHOD	-
HORIZONTAL SCALE 1 : 2400	DATUM M.S.L.
TYPE OF PROFILING	TRANSPOSED
TRACE INTERVAL	132'
OFFSET DISTANCE	1386-2574' & 2706-3894'
No. AND TYPE OF VIBRATORS	3
SWEEP FREQUENCY 14-40	No. OF SWEEPS 10
PLAYBACK FILTER	OUT - 42
MIXING	3/2 COMPOSITED

VIBRATOR PATTERN:
1888W - 1891A W 396' IN LINE
1865W - 1877E 132' IN LINE

GEOPHONE PATTERN:
RECTANGULAR

PARTY 243	DATE FEBRUARY 1965
ENCLOSURE No. 80	FIELD AREA REPORT

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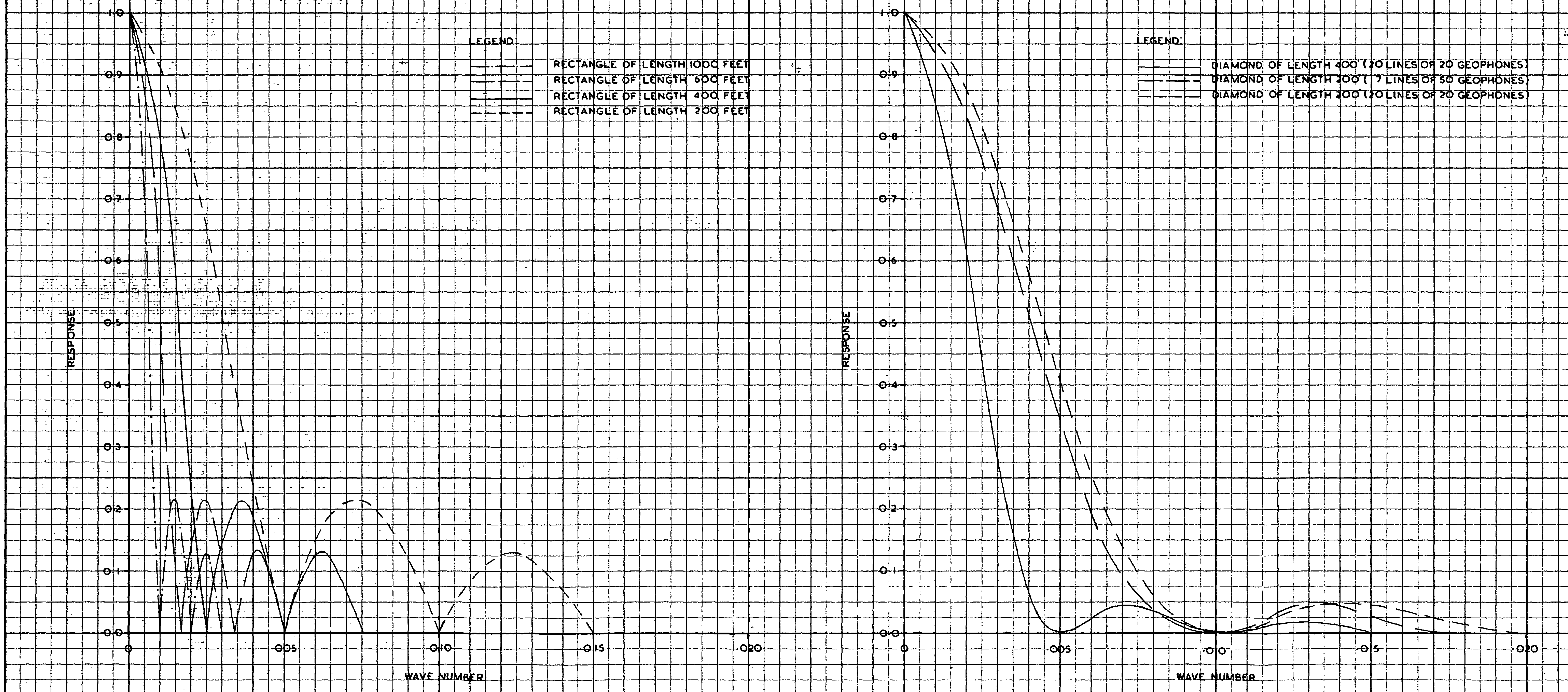
SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

DIAGRAM FOR 10-FOLD C.D.P. FIELD LAYOUT

LOCATION	HAMILTON
PARTY CHIEF	T. L. KENDALL
PARTY 243	DATE: FEBRUARY-1966
ENCLOSURE No. 81	FIELD AREA REPORT



SEISMOGRAPH SERVICE LIMITED
LONDON ENGLAND

FOR BUREAU OF MINERAL RESOURCES

PATTERN RESPONSE CURVES

PARTY CHIEF T. L. KENDALL
PARTY 243 DATE: FEBRUARY-1965
ENCLOSURE No 82 FIELD AREA REPORT