

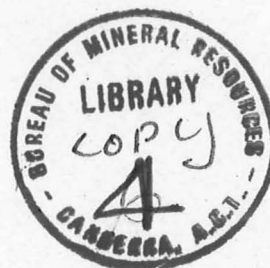
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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**EXPERIMENTAL SEISMIC SURVEY USING EXPLOSIVES
FOR COMPARISON WITH A 'VIBROSEIS' SURVEY
IN THE OTWAY AND SYDNEY BASINS, 1965 AND 1966**

by

**E.H. Schwing (Institut Francais du Petrole)
and F.J. Moss**

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SUMMARY

The Bureau of Mineral Resources made an experimental seismic survey in the Otway Basin, Victoria and SA, and in the Sydney Basin, NSW, from April to November 1965 and from mid-February to mid-March 1966. The survey used explosives as an energy source to obtain seismic reflection data for comparison with the results from an experimental 'Vibroseis' survey carried out for the Bureau by Seismograph Service Ltd during 1964.

The areas surveyed were areas of volcanic cover in southwest Victoria, Gambier Limestone and sand dune cover in southeast SA, and Hawkesbury Sandstone cover in NSW. They were considered to be seismic problem areas from the results of previous seismic work with difficulties caused by poor energy transmission, seismic noise, variable weathering conditions, difficult drilling, and in accessibility for seismic work. A program of preliminary tests to determine the physical conditions in the test areas, experimental recordings to study the various recording parameters, and production recording was made on traverses common to the 'Vibroseis' survey. The time spent on experimental recording and the amount of recording were approximately the same as for the 'Vibroseis' survey, and a full test program was made despite the fact that the results from the experimental 'Vibroseis' survey were available before the comparison survey began.

Fair quality results at least comparable to the 'Vibroseis' results were obtained in most areas. In the volcanics, Gambier Limestone, and sand dunes areas, the main problems found to affect the quality of the seismic results was longitudinal, transverse, and random noise. Up to 48 geophones per trace in areal patterns and long in-line geophone and shot-hole patterns giving wavenumber cut-offs of from 2 cycles/300 m to 4 cycles/300 m were necessary to attenuate the noise events. Energy transmission problems were overcome mainly by the use of large charges, up to 136 kg, placed below the weathered layers. Other problems in the survey areas were found to be of minor significance. In the Hawkesbury Sandstone area, energy transmission was poor and large charges, up to 227 kg, were necessary with the charges split into small unit charges in a large number of well tamped holes. Longitudinal noise was attenuated with long in-line shot and detector patterns giving wavenumber cut-offs of approximately 2 cycles/300 m to 3 cycles/300 m. It was not always possible because of accessibility problems to lay areal patterns to attenuate random noise effectively. A 50Hz notch filter was used to attenuate 50-Hz pick-up in the area. Drilling was not a major problem and weathering variations were not significant.

The varying of recording parameters on the experimental comparison survey was more difficult than on the 'Vibroseis' survey. The 'Vibroseis' survey had some advantages in the use of controlled sweep frequencies, the use of cross-correlation techniques to provide sharp cut-off filters and to discriminate against random noise, and the ease with which a high multiplicity of vibrator points and geophones could be used for relatively low cost. The experimental seismic survey had a clear advantage over the 'Vibroseis' survey in placing the explosive charge in consolidated rock below the weathered layer.

1. INTRODUCTION

The Bureau of Mineral Resources (BMR) employed Seismograph Service Ltd (SSL) in 1964 to demonstrate the performance of the 'Vibroseis'* system in some problem areas of the Otway and Sydney Basins (Seismograph Service Ltd, 1965; Moss, 1965). The method, which uses a vibrator on the surface as an energy source, is described by Crawford, Doty & Lee (1960), Smith (1963), Schwing (1964), and more recently by many other authors.

The objectives of the experimental 'Vibroseis' survey were to show the capabilities of the method in difficult areas, to assess the cost for comparison with shot-hole seismic surveys in these areas, and in so doing to assess the general potential of the method. In the Otway Basin, the areas surveyed were areas of volcanic cover in southwest Victoria, areas of Gambier Limestone cover, and sand dune cover, and an interdunal poor reflection area in southeast South Australia. In the Sydney Basin, Hawkesbury Sandstone covered areas in the central part of the Sydney Basin and the densely populated, built-up Maitland area were surveyed.

A shot-hole seismic survey using explosives, which is the subject of this report, was made in all but the built-up and interdunal areas, from April to November 1965 and from mid-February to March 1966. The purpose of the survey was to obtain seismic data in the areas that had been surveyed using the 'Vibroseis' method, in order to provide valid comparisons of data quality and costs between the two methods. The general program consisted of preliminary testing to measure the physical conditions, experimental recording designed to study the various recording parameters, and production recording.

Since the seismic survey, much new information has been obtained in the problem areas of the Otway and Sydney Basins from wells and further geophysical surveys; however, no attempt has been made in this report to update the accounts of the geology of the basins or to include the results of more recent geophysical surveys.

The staff and equipment and operational statistics for the survey are indicated in Appendices 1 to 4. Conversions of distances and weights from imperial to metric units were made after the survey was completed.

* Trademark of the Continental Oil Co.

2. OTWAY BASIN SURVEYS

INTRODUCTION

The experimental seismic surveys in the Otway Basin were made from mid-April to September 1965 and from mid-February to March 1966 (Raitt, 1966; Jones, 1966). The areas selected as common test sites for the 'Vibroseis' and the experimental surveys for comparison were as follows:

- (1) Basalt covered areas north and northeast of Portland
- (2) Gambier Limestone outcrop area south of Mount Gambier
- (3) Sand dune covered area north of Mount Gambier

GEOLOGY*

The Otway Basin is a Cretaceous and Tertiary depositional area extending from near Geelong in Victoria to Robe in South Australia (Plate 1). It covers an area of approximately 34 000 km² on land and probably also includes a large area of Cretaceous and Tertiary deposits offshore.

Onshore the Otway Basin has been divided in the past into a number of sub-basins, sunklands, and embayments. However, the petrological and geophysical study of the Otway Basin by BMR (Reynolds, 1971) showed that most stratigraphic units are basin-wide in extent and that the concept of distinct sub-basins is probably unjustified. They have been used in this report for ease of identification of survey locations. A major basement feature within the Otway Basin - the Warrnambool Ridge (Reynolds, Evans, Bryan & Hawkins, 1966) - caused a marked thinning of the succession in the Warrnambool/Port Fairy area where the Pretty Hill No. 1 well was drilled, but even there all the major stratigraphic units are present.

A large part of the Otway Basin in Victoria is marked by very extensive basalt flows, the 'Newer Volcanics' of Pliocene to Quaternary age. Tertiary limestones are also common in the basin, and in South Australia large areas are covered by Quaternary sand and gravel. The Upper Cretaceous sequence is absent in outcrops, and significant outcrops of Lower Cretaceous sediments occur only in the Otway Ranges and the Geelong and Casterton areas of Victoria.

*Summary by Mr R. Bryan formerly of BMR, Petroleum Exploration Branch.

The Mesozoic and Tertiary stratigraphy of the Basin has been discussed in detail by BMR (1971), and the Cretaceous stratigraphy has been discussed by Reynolds et al (1966). The generalized stratigraphy of the Otway Basin is summarized in Table 1.

TABLE 1 : STRATIGRAPHY OF THE OTWAY BASIN

AGE	GROUP FORMATION	LITHOLOGY	
Quaternary		Gravel sand, mudstone, limestone	'Newer Volcanics' Olivine basalt, minor tuff agglomerate
Pliocene		Gravel, sand, sandstone, limestone in part phosphatic	
Miocene	HEYTESBURY GP (850m)	Polyzoal limestone, marl	
Upper Eocene	NIRRANDA GP (110m)	Limonitic marl, sandstone, conglomerate	'Older Volcanics' Olivine basalt, minor tuff agglomerate
Mid Eocene	WANGERRIP GP (850m)	Carbonaceous sandstone, siltstone, chamosite oolite, siderite rock, pebbly sandstone	
Paleocene			
	Curdies Fm (400m)	Sandstone conglomerate, coaly horizons	
Upper Cretaceous	SHERBROOK GROUP	Paaratte Fm (850m)	Siltstone, sandstone with Kaolinite and carbonate cement
		Mt Salt Fm (1070m)	Mudstone, siltstone and sandstone with chlorite glauconite pyrite Belfast Mudstone (637m) Glauconitic and pyritic mudstone
			Flaxmans Fm (85m) Chamositic and phosphatic oolite, sandstone
Lower Cretaceous	OTWAY GROUP	Eumeralla Fm (2740m)	Greywacke, subgreywacke volcanic sandstone, siltstone, mudstone, coal Maarre Fm Sandstone, mudstone, some coal
		Geltwood Beach Fm (1020m)	Sandstone with garnet, interbedded mudstone, greywacke (Equivalent: Pretty Hill Sandstone)
Jurassic		Poorly sorted sandstone, shale, conglomerate.	
	Conformable Boundary		
	Disconformity or Unconformity		

VOLCANICS PROJECT

The area around Portland, Victoria, was the scene of much volcanic activity during the Tertiary period and there are a number of volcanic craters and lava flows still in evidence. Several problems inherent in the presence of the volcanics have hampered seismic activities in the area. These include problems of energy transmission, multiple reflections, and hard drilling.

Basalt, tuff, and other volcanic matter which covers much of the area north and northeast of Portland form a screen through which it is difficult to transmit energy to the geological section beneath and to receive energy back. These difficulties are commonly encountered in areas with high-velocity layers on or near the surface.

Multiple reflections are evident on most seismic recordings made on or near the basalt-covered areas: they are very strong on recordings made in the area just north of the Pretty Hill No. 1 well (Frome Broken Hill, 1962). The synthetic seismogram from this well (Plate 3) confirms that multiples are likely to be a problem in this area. It indicates good reflecting conditions at the top of the Wangerrip Group at 1100 ft (340 m), at the top of the Otway Group at 2890 ft (880 m), and at basement at 7880 ft (2400 m). Weak reflecting conditions are indicated for the 'Pretty Hill Sandstone'. The synthetic seismogram shows filtered primary reflections plus filtered first-order surface multiples, the strongest of which appear to be multiples with reflection paths between the surface and the top of the Wangerrip Group. When shooting is done on basalt, reverberation-type multiples, similar to ringing found in marine seismic work, are often present on the seismic records.

Drilling in hard basalt is very slow and often difficult and costly. The drilling rate, using a Mayhew 1000 combination drill, may be as slow as 3 cm per hour.

The site selected for the initial 'Vibroiseis' survey on the Volcanics Project, and hence the site for the comparison work, was near Hamilton, Victoria (Plate 2). Outcrops of basalt flows, mostly from Mount Napier, an extinct volcano, have rendered the area particularly unsuitable for seismic work using explosives in drill holes.

Previous Seismic Information

BMR made the first seismic tests on basalt areas in the Otway Basin, near Heywood, Victoria, in 1956 (Lodwick & Vale, 1958). During the period from 1956 to 1965 seismic crews from the South Australian Department of Mines, and contractors employed by the holders of petroleum exploration permits and licences have shot about 4350 km of traverses using seismic methods with explosives in shot-holes; this work has been done in the coastal areas of the Portland Sunklands, in the Gambier Sunklands, and offshore from the coast of southwest Victoria (Reynolds, 1971). The offshore work was generally successful. It indicated a deep structural trend parallel to the coast in the west-north-west direction and a series of very gentle east-northeast trending folds, parallel to the Otway Ranges, in the shallower part of the sedimentary section.

On land, seismic work yielded good results in many areas. But no simple technique yielded good results throughout the basin, and there were large areas where the seismic reflection data were poor or where no seismic reflections had been obtained. Areas with volcanic cover, sand dunes, and Gambier Limestone cover had been avoided generally and difficulties had been experienced in the limited seismic work done.

Shot-hole Seismic Surveys. Most seismic traversing in the Otway Basin had been done in the Portland/Port Campbell coastal area which has no basalt cover. Seismic results of fair quality were obtained there with a relatively minor effort. Single-coverage techniques were used generally with 12 geophones per trace, up to 8 m apart in line, and 3 holes 23 m apart in line with charges of 2 kg to 7 kg per hole loaded to depths of up to 46 m.

Considerable testing was done in areas mainly bordering the basalt-covered areas where reflection quality deteriorated. The tests, involving increasing the number of holes per shot-point and the number of geophones per trace and experimenting with hole depths and charge sizes, indicated that increasing the effort factor generally improved the reflection quality. During the Dartmoor-Nelson seismic survey (Frome Broken Hill, 1962), seismic reflection results were slightly improved only by using an increased effort with 10-hole patterns, a total charge of 113 kg, and 24 geophones per trace.

In addition to the above testing, noise spreads were shot in a number of surveys. Noise spreads shot on tuff or weathered or hard basalt were not recorded continuously out from the shot-point; thus the results are difficult to analyse. And it was evident that the noise characteristics vary over small areas.

The Branzholme-Koroit reconnaissance seismic survey (Frome Broken Hill, 1964) was made on volcanics cover north of the Pretty Hill No. 1 well to investigate the northward extension of the basin in this area. Results, mainly from 6-fold CDP coverage, were fair despite the difficulties in obtaining good static and dynamic corrections. Although multiple reflections were apparent on single-coverage sections they were attenuated significantly on the CDP stacked sections.

Vibroseis Survey, 1964. The experimental 'Vibroseis' survey was done south of the volcanics covered area near Pretty Hill No. 1 well (Traverse V1) and on areas of volcanics cover near Mount Napier (Traverse V2) and north of Heywood (Traverse V3) during a 6-week period in May and June 1964 (Seismograph Service Ltd, 1965; Moss, 1965). Recordings were made along Traverse V1 to test the 'Vibroseis' method initially in an area of good reflection. In addition, a sonic log was available from Pretty Hill No. 1 well from which synthetic seismograms (Plate 3) had been made. Transposed and 10-fold CDP coverage along a 3-km traverse yielded poor to fair results of comparable quality to those obtained from previous shot-hole work.

On Traverse V2, noise spreads were recorded and detailed experiments were made using different vibrator and geophone patterns, number of vibrator sweeps, geophones to vibrator offsets, and sweep frequencies. The tests indicated that surface noise with velocities in the range 1460 m/s to 2740 m/s should be attenuated significantly by the vibrator and geophone patterns. The optimum transposed technique found used vibrator patterns 120 m long and geophone patterns 120 m long by 60 m wide. A vibrator sweep from 20 to 57 Hz was most effective on Traverse V2. The effective sampling using the transposed method was within the range of 8000 to 12 000 separate ray paths. Part of Traverse V2 was resurveyed using 10-fold CDP coverage with source and detector patterns 81 m long. The CDP results were of better quality and the continuity of the reflections was better despite the reduction in pattern lengths. A constant weathering depth of 7.6 m was assumed along the traverse and it was found that when the source and detector patterns used were long enough to result in ground mixing, variations in weathering depth were not critical.

Reflection quality varied from poor to fair on Traverse V2. A high-amplitude reflection was recorded intermittently between 0.5 and 1.0 s reflection time along the traverse, with poor continuity in the northern part of the traverse and fair continuity towards the south. Continuity was best about VP 180. The origin of the event was not determined, but from its character and the absence of reliable deeper events it was assumed to be a reflection from basement. In the southern part of the traverse there was interference between this event and steeply dipping events tentatively identified as multiple reflections.

The transposed and CDP recording methods used on Traverse V2 were used again on Traverse V3 to test their applicability in a different area of volcanic cover. Intermittent reflections of fair quality were recorded on Traverse V3 at approximately 0.5, 0.9, and 1.3S. There was a high ambient noise level on recordings along Traverse V3 due mainly to traffic, rain, wind, and trees along the traverse.

The 'Vibroseis' survey results indicated that a surface method, with long source and detector patterns and a large number of ray paths composited, could be used to provide subsurface information in areas covered by the volcanics. However, the results obtained on the isolated traverses posed problems in interpretation of geological structures.

Velocity Information. The most reliable velocity information in the basin in the area of the survey was that obtained from some logs and well-geophone surveys. Sonic logs were available from Pretty Hill No. 1, Emmeralla No. 1, and other recent wells in the area. The 'Vibroseis' results were dynamically corrected using the velocity function derived from the sonic log information in Pretty Hill No. 1 well.

Program and Results

The seismic program was designed to record along the Traverses V2 and V3 (Plate 4) of the 'Vibroseis' survey in order to obtain a direct comparison between the 'Vibroseis' and shot-hole information (Raitt, 1966). Traverse V1, near Pretty Hill No. 1 well, was not reshot since it was not on volcanics cover and had been surveyed on the 'Vibroseis' survey only to evaluate the 'Vibroseis' results in a fair-reflection area prior to work in the more difficult areas, and to obtain a 'Vibroseis' record from the basin section near the well for correlation purposes.

Wet weather in 1965 forced the abandonment of production recording on part of Traverse V2 and on Traverse V3. This work was completed in 1966.

Uphole Survey (Traverse V2, SP181). Twelve shots were fired at depths from 76 m to the surface, and recordings were made using 8 bunched geophones per trace on a normal seismic spread. The results (Plate 5) indicated a layer of velocity 550 m/s to a depth of 7 m, and a sub-weathering vertical velocity of 3050 m/s. The first breaks on the normal spread indicated a sub-weathering horizontal velocity of 3660 m/s. The sharp increase in velocity at the base of the weathered layer is evident on the wave-front diagram plotted from the uphole survey (Plate 6).

Noise Analysis (Traverse V2, SP180). Charges weighing 9 kg were shot at a depth of 24 m into 5 spreads laid between 91 m and 1180 m northward from SP180. The trace interval was 9 m, and eight 14-Hz bunched geophones were used per trace. Recordings were made with linear gain, to measure relative amplitudes, and 18-Hz pre-filters with a slope of 12 dB per octave. A transverse noise spread was laid through SP181, at a distance of 268 m from SP180, with one geophone per trace and at 8 m trace interval.

Record sections of the noise recording with and without AGC are shown in Plate 7; the time-distance graph is shown in Plate 8, and the frequency response, amplitude, and wavenumber response graphs are shown in Plate 9. The velocity, apparent mean frequency, and highest significant amplitude of each event compared to the amplitude of Event No. 1, which corresponds to an input voltage of 32.8 mV. The background noise level was found to lie generally between 10 and 30 microvolts, but in windy periods it rose to about 100 microvolts.

The events numbered 2 and 10 have low wavenumbers and could be considered to be troublesome. They are thought to be refraction events on the basis of their velocities and apparent lack of moveout curvature, but because of their offset distances they should not affect the quality of reflection events. Event No. 10 appears to be a refraction event with velocity 5490 m/s, closely related to the main reflection band in the section between 0.75 s and 0.85 s. From the frequency and wavenumber spectra, it is noted that Events Nos 7 and 15 have very low wavenumbers. They are apparent only after the noise events of higher amplitude and shorter duration have faded, but could pose a residual problem after attenuation of the more troublesome noise events of higher amplitude. These are events numbered 1, 3, 4, 5, and 6 with wavenumbers of about 6 or more cycles/300 m, and

should be attenuated significantly by the normal shot-hole and geophone patterns used. Minor events numbered 8, 11, 12, 13, and 14 should also be significantly attenuated. Two wavenumbers were computed for Event No. 9, interpreted as a reflection because of its curvature, by choosing apparent velocities for the intervals from 0 to 268 to 537 m. The wavenumbers indicated the increase in signal attenuation likely to result from an increase in spread length.

Interference between longitudinal and transverse noise events may be seen on the transverse noise spread record (Plate 7). No parameters were computed for the transverse noise events since they are ill-defined and of low amplitude. A reverse noise event may be seen on the record section from the remotest spread, at a time of approximately 1.2 s. This event has a low velocity and low amplitude.

The main signal frequencies on the reflection records were found to be between 25 and 35 Hz, with frequencies from 30 to 33 Hz predominating. This placed a limit on the low-cut electrical filtering and it was found that low-cut filters above 21 Hz destroyed the character of the signal. Accordingly recordings were made with an 18-Hz pre-filter with a slope of 12 dB per octave. A high-cut filter of K92 was used in recordings and the best playback filters were found to be K21-K75.

Analysis of the results of the noise test indicated that a wavenumber cut-off of to 4 cycles/300 m would be necessary to attenuate the noise events significantly. A detector or shot-hole pattern length of 91 m would provide the necessary spatial filter to attenuate the main noise events Nos 1, 3, 4, 5, and 6 and the very low wavenumber events Nos 7 and 15. Although the noise events of high amplitude should be attenuated, at the main reflection frequencies by about 30 dB, the signal may be also attenuated appreciably by as much as 15 to 20 dB for the outermost traces of shallow reflection events.

Experimental Recordings. The main experimental work was done on Traverse V2. As difficulties in operational and climatic conditions often prevented the repetition of a test at the same place and under the same conditions, several comparisons were made at different places. Some conclusions on parameter comparisons had to be made from comparisons of records shot under different conditions and with more than one parameter varied.

The recording instrument settings, selected from experience gained from previous shot-hole surveys and the 'Vibroseis' surveys, were as follows:

Amplifier Filters	Recording 0-K92
	Playback K21-K75
AGC	Medium
Presuppression	-60 dB
Ultimate Sensitivity	-20 to -30 dB
Pre-filter	18 Hz, 12dB/octave
LLI	10 mV input full deflection

A spread length comparison test was made. A test was made with a spread of 537 m between SP180 and SP182, and a spread of 268 m which conformed to that used in the 'Vibroseyis' survey. The geophone pattern of length 91 m, indicated as being necessary from the results of the noise tests, resulted in substantial ground mixing on the 268-m spread, and the very shallow section prevented the use of a long spread. Thus a spread length of 366 m was used as a compromise. With this spread, ground mixing was reduced by a factor of 4 to 3, but signal was attenuated more at the longer offsets than with the shorter spread. The main reflection band at 0.75 s was of sufficiently high amplitude to withstand the additional attenuation resulting from the increased spread lengths; the outer traces of the shallow reflection events were attenuated but the noise attenuation was sufficient to give an overall higher S/N ratio.

Charge comparisons and optimum shot depth determinations were made at SP179B, SP180, SP181B, and SP184B. (Plate 10). Comparisons of various charge sizes at SP180 and SP181B showed that with a total charge of up to 9 kg there was a slight increase in S/N ratio for the shallow reflection events with the increase in charge size. A reduction in the charge size to 2 kg attenuated the amplitude of low-frequency events recorded below 0.8 s at the expense of lowering the quality of the shallow reflection events. The optimum unit charge was taken to be 9 kg. The general energy return for a total charge of 45 kg as indicated by the LLI was an initial peak at 3 m to 10 mV followed by a gradual decay to between 1 and 3 mV until the main reflection events, when it again rose above 3 mV. The decay rate was approximately 15 dB/s and a background noise level of 10 to 30 microvolts was reached normally between 2.5 and 3.0 s.

The comparison at SP181B between charges of 5x9 kg and 5x1 kg was made to examine the effect of a large decrease in charge on the amplitude of the low-frequency events recorded after the main reflection event at 0.8 s. Other comparisons were made at SP179B between charges of 7x2 kg and 7x9 kg and at SP184B where charges of 7x1 kg were compared with 7x9 kg.

The heavier charges yielded better results in both cases (Plate 10).

Optimum shot-depth comparisons were made initially between SP180 and SP182 with geophone pattern of 16 per trace with geophones 6 m apart in line, with 9 kg charges fired at the base of a hard basalt layer, in the hard basalt layer, at the top of the hard basalt layer, and in the clay and weathered basalt. Shooting in the hard basalt gave the best results and it was decided, on the basis of energy level and reflection quality, that the charge be placed between 24 m and 27 m where a thick band of basalt was present.

Shothole pattern comparisons were made at SP179, SP180B, and SP181B. In-line shot-hole patterns of 3 holes 15 m apart with charges of 14 kg per hole, and 5 holes 15 m apart with charges of 9 kg per hole, giving wavenumber cut-offs of 6.7 cycles/300 m and 4.0 cycles/300 m respectively, were compared at SP179 (Plate 11). The 5-hole pattern gave better results.

Similar tests were made at SP180B. A comparison at SP180B between 4 holes 30 m apart 15 m apart, and 7 holes 15m apart indicated an improvement in reflection quality with an increase in the number of holes (Plate 11). The hole spacing of 30 m in the 4-hole pattern appeared to be too large for adequate filtering.

During this comparison test the geophone pattern was varied from 48 geophones per trace in 2 rows of 24 in line, with rows 9 m apart and geophone 6 m apart, to 2 rows of 16 in line with the same spacing, corresponding to a wavenumber cut-off of 3.1 cycles/300 m, with slightly improved results.

Geophone pattern comparisons were made at SP180B, SP181B, and SP182B. Comparisons were made between 16 geophones per trace, 6 m apart in line; 32 geophones per trace in 2 rows of 16 in line, with rows 9 m apart and geophones 6 m apart; 24 geophones per trace, 5 m apart in line; and 48 geophones per trace in 2 rows of 24 in line, with rows 9 m apart and geophones 5 m apart. Comparisons at SP180B and SP181B between the use of 1 and 2 rows of 24 geophones, giving a wavenumber cut-off of 2.5 cycles/300 m, are shown in Plate 12.

A comparison between the records from SP182 with 5 holes 15 m apart in line and 16 geophones per trace, 6 m in line and SP182B with 7 holes 15 m apart in line and 2 rows of 24 geophones per trace, with rows 9 m apart and geophones 5 m apart is shown in Plate 12.

Production Recording. Production recordings were made on Traverses V2 and V3. Production tests were made on Traverse V2 from SP180 to SP170 and a technique giving satisfactory results was achieved at SP172B by gradual variation of the recording parameters from shot-point to shot-point. The details are as follows:

Spread Length	366 m
Shothole pattern	7 holes, 15 m apart in line Charge 7 x 9 kg at 24 m/27 m
Geophone Pattern	48 geophones per trace in 2 rows of 24 in line, with rows 9 m apart and geophones 5 m apart.

This technique, with instrument settings defined by the experimental recording, was used to complete shooting Traverse V2 from SP180B to SP189B during 1965. It was also used on Traverse V2 from SP190B to SP195B and on Traverse V3 in 1966.

Reflection events of fair quality were recorded on Traverse V2 (Plate 13). The most outstanding event is at times ranging from 0.6 to 0.95 s along the traverse, and slightly shallower events with poorer continuity were recorded between SP189B and SP194B and between SP181B and SP184B. Several abnormal events are present on the record section, with vertices at times of 0.7 s at SP175B, 0.5 s at SP18B and 1.0 s at SP187B and SP194B. These events cause interference with, and loss of continuity of, the main reflection event. Low-frequency events are also evident after the main reflection event over most of the section.

A $t:\Delta t$ analysis (Plate 15) made from the production records shows an initial decrease in average velocity because of the high-velocity effect of the near-surface basalt. A velocity function of $V_i = 2185 + 0.65 d$ was found to be the best fit.

The technique developed on Traverse V2 was tried on Traverse V3 to see if it might be applicable generally in volcanics areas. The record section obtained on Traverse V3 (Plate 14) differs from that obtained on Traverse V2. Reflection events of poor to fair quality with south dip are evident at between 0.4 and 0.9 s, but there is little coherent energy below these events.

Discussion of Results. Surface problems expected to occur were energy transmission, variations in the thickness and velocity of the weathered layer, and hard drilling. Subsurface problems expected were lateral velocity variations and multiple reflections.

The best energy transmission was obtained when the charge was placed within a hard basalt layer; charges of 45 to 64 kg gave sufficient energy input to approximately 2.5 s record time. Although the near-surface formations penetrated in the shot-holes varied in thickness and extent, no large variations in weathering times were detected. Drilling conditions were variable, but the average penetration rates between 15 m and 37 m per hour achieved were considered reasonable.

No consistent lateral velocity variations were observed although the $t: t$ points are well scattered on the graph (Plate 15). No multiple reflections were identified in the section above the main reflection. It is possible that the low-frequency recorded immediately after the main reflection event represents reverberation-type multiples.

In the volcanics area the sedimentary section appeared to be thin, but no holes were drilled to confirm this. The geophone and shot-hole arrays, defined in the optimum technique, significantly attenuated the longitudinal noise, but also attenuated shallow reflections, thus making it difficult to obtain good quality shallow reflection records without shortening the spread length. Costs of seismic coverage would increase proportionally to decrease of spread length.

Although little transverse noise was recorded during the noise test (Plate 7), the irregular nature of the near-surface basalt was such that transverse noise could be a problem. The curved event on the record section (Plate 13) with its vertex under SP183B was considered to be a reflected refraction with its path in the near-surface basalt. A curve computed for a reflected refraction, using 3660 m/s, the horizontal velocity in the basalt, was found to be in fair agreement, whereas a diffraction curve was found to have a different curvature. Several weaker events of similar curvature to the reflection refraction interfere with the shallow reflections. The events with vertices at SP175B and SP187B are considered to be diffraction patterns; curves computed, using the velocity function for the area and assuming an origin in the vicinity of the main reflection event, agreed closely with those observed, suggesting that they are diffraction patterns emanating from fault planes.

The main reflection event exhibits an overall dip to the north with a fairly sharp reversal at SP191B. The depth to the reflecting horizon varies between 790 m and 1310 m. No deeper reflecting horizons were noted. Faults postulated at SP175B and SP187B would be of small throw, probably to the south.

Conclusions

The following conclusions were reached as a result of the experimental and production seismic reflection work on Traverses V2 and V3:

- (1) A fairly high-effort technique, evolved from an experimental program, was necessary to produce reasonable seismic reflection results in the volcanics areas. The applicability of the technique to work on Traverses V2 and V3 suggested that this technique could give reliable results in other volcanics areas.
- (2) None of the expected problems proved to be insurmountable barriers to obtaining seismic results in the volcanics areas. Surface noise, although not severe in noise test recordings, could be the most intractable problem.
- (3) Reflected refractions with paths in the near-surface basalt layers, and diffraction patterns originating from minor faults, interfere with the main reflecting horizons.
- (4) Shortening the spread length and using areal patterns to attenuate traverse noise events could possibly improve the quality of shallow reflections at the expense of increased exploration costs.
- (5) The main reflecting horizon is tentatively identified as basement varying in depth from about 790 m at the southern end of Traverse V2 to about 1310 m at SP191B. There is a lack of coherent energy below the event; it has similar characteristics to those found on previous surveys, viz. two or three phases, with a tendency to bifurcate, followed by a band of lower-frequency energy. This lower-frequency energy remains unaffected by the changes in patterns; thus it may be assumed to originate within the section. It is particularly strong in the vicinity of the diffraction patterns, where there is an overall energy increase.
- (6) The seismic survey results on Traverse V2 compare favourably with those obtained previously by conventional and 'Vibroseis' surveys.

GAMBIER LIMESTONE PROJECT

Gambier Limestone is a white soft friable limestone with occasional flint beds, very cavernous in the area to the southeast of Mount Gambier. It extends eastwards to the Portland area, where it is less cavernous. Problems associated with seismic work in the limestone area are problems in energy transmission, seismic noise, and difficult drilling.

The transmission of energy through the cavernous limestone was considered to be difficult although the results of the 'Vibroseis' survey had indicated that the problem could be less serious than initially envisaged. The 'Vibroseis' survey indicated a noise problem. Drilling on previous seismic surveys was difficult and costly because of circulation problems and a low penetration rate through flint beds in the limestone sequence.

Previous Seismic Information

Seismic traverses shot by the South Australian Department of Mines, and contractors employed by the petroleum exploration licensees in the Gambier Sunklands were of a reconnaissance nature. The techniques used were generally simple, and little experimental work, other than normal testing with hole depths and charge sizes, had been conducted in poor-reflection areas.

Single holes 9 m to 18 m deep with a charge of 2 kg to 5 kg, shot into conventional split spreads with 4 geophones per trace, normally with 3m to 5 m between geophones, gave fair-quality results in most areas but poor results in Gambier Limestone areas.

Vibroseis Survey, 1964. An experimental 'Vibroseis' survey was made in areas of outcropping Gambier Limestone during a 6-week period in June and July 1964 (Seismograph Service Ltd, 1965; Moss, 1965).

The main experimental recordings were made on Traverse GL2, located 3 km west of Mount Schank (Plate 16). Noise spreads indicated three discrete high-amplitude events with velocities of 760 m/s, 1000 m/s, and 2200 m/s. Experiments were made and 6.4 km of continuous coverage on Traverse GL2 was made using a transposed method. Diamond-shaped detector patterns 122 m long by 122 m wide, and source patterns 61 m long, were used with a sweep of 14 Hz to 51 Hz. Effective sampling was over 24 000 separate ray paths. Reflection events were of poor quality, being

interfered with by low-velocity, high-amplitude noise events which were not attenuated effectively using the transposed method. Part of the traverse was resurveyed using 10-fold CDP coverage with source and detector in-line patterns 61 m long. The CDP results were of better quality, the interfering noise events being considerably attenuated.

Reflections were recorded to about 2.3 s; the continuity of shallow reflections between 0.8 and 1.0 s reflection time was good but the continuity of deeper reflections was poorer, especially at the ends of the traverse. The CDP work did not improve the quality or continuity of the deeper events; thus the possibility that the deeper events might be multiple reflection" could not be discounted.

Recordings were made on Traverse GL3 near Glencoe, about 24 km northeast of Mount Gambier, to test the applicability of the methods from Traverse GL2 to another area of Gambier Limestone cover. The coherent noise level was found to be much lower on this traverse. Fair-quality reflection events, recorded to 1.0 s, and poorer, less continuous events to approximately 2.8 s, were of comparable quality to those obtained on previous shot-hole surveys.

Generally the 'Vibroseis' survey gave fair-quality reflection information, but record sections indicated persistent high-amplitude interfering noise events which appeared to limit resolution by the method.

Velocity Information. Vertical velocity information was found from $t:\Delta t$ analyses and from well velocity information. From previous surveys the velocity functions $v_a = 1615 + 0.65 d$ and $V_a = 1920 + 0.3 d$ were found to apply in the areas north of Mount Gambier and in the Beachport area, respectively. The 'Vibroseis' results of Traverse GL2 were overcorrected using the Beachport area function, to the velocity function $V_a = 2113 + 0.25 d$, from Geltwood Beach No. 1 well, was used for correcting the results.

Program and Results

The seismic program was designed to record experimental work as for the 'Vibroseis' survey on Traverse GL2 and production recording on Traverses GL2 and GL3 (Jones, 1966; Plate 16). Part of Traverse GL2 was reshot in 1966 because instrumental crossfeed was found on some of the production records from 1965.

Uphole Survey. Traverse GL2, SP689. The uphole survey was shot from a maximum depth of 62 m to the surface, with recordings made on a split spread of length 1073 m, with 24 geophones per trace, 3 m apart in line. The results indicated a best shooting depth of about 18 m. The uphole survey showed (Plate 17) a sub-weathering layer with vertical velocity of 2195 m/s to a depth greater than 70 m. The horizontal sub-weathering velocity as measured from the first breaks along the traverse was also 2195 m/s. The weathering depth was fairly consistent at about 6 m along the traverse, and the velocity of the weathered layer was approximately 610 m/s.

Noise Analysis. Traverse SG2, SP689. The noise spread extended 1180 m to the west with the nearest geophones at 91 m, and the trace spacing was 9 m with eight 14-Hz geophones per trace. Charges varying from 5 kg to 14 kg per shot were fixed at a depth of 18 m. Shots were recorded with linear gain, varied according to the distance from the shot, and 18-Hz pre-filters with a slope of 12dB per octave. A transverse noise spread was recorded at a distance of 524 m from SP 689, with 8 geophones bunched per trace and with 8-m trace interval.

Record sections of the noise recordings with and without AGC are shown in Plate 18; the time distance graph is shown in Plate 19 and the frequency response, amplitude, and wave number response graphs are shown in Plate 20. The first refracted arrivals indicate a velocity of 2210 m/s. There are three main noise groups: the most significant, with a velocity about 732 m/s and a main frequency about 20 Hz, is strongest beyond 610 m from the shot-point; the second group is a fairly continuous low-amplitude event with a velocity of about 975 m/s and a frequency of about 30 Hz; and the third group, of low-amplitude discontinuous events, has a velocity of about 1646 m/s and a frequency of about 45 Hz. Some high-frequency noise not apparent in the noise test was recorded later during experimental shooting and was detrimental to the quality of the data.

Events numbered 23 to 28 were considered to represent seismic signal. They have high apparent velocities and a centre frequency of about 35 Hz and are well separated from the noise from wavenumber considerations. A spatial filter of 4 cycles/300 m would be adequate to attenuate the coherent noise recorded, and as the signal events apparently have very little dip, a large margin could be allowed in spatial filtering.

Some transverse noise is evident (Plate 18) with a fairly strong arrival at about 1.0 s with velocity 658 m/s and frequency 30 Hz. This noise would be attenuated adequately with a wavenumber filter of about 13 cycles/300m or less. The records from the various charges used in recording the noise test suggested that both the noise and signal levels increased with charge size, but results were inconclusive.

Expanded Spread Traverse GL2, SP691 (Plate 21). The $t^2: x^2$ plot indicates a velocity function $V_1 = 2134 + 0.55d$ to a depth of approximately 3350 m (Plate 22). There is no evidence of multiple reflections in the expanded spread record section.

Experimental Recordings. The main experimental work was done on Traverse GL2.

Depth Comparisons were made at SP693 and SP687. At SP693 six recordings were made with 5-kg charges at depths from 12 m to 29 m (Plate 23). The quality of the records was poor generally, but there was a slight improvement in the quality of the shallow events with increasing depths of charges to 24 m.

At SP687, comparison recordings were made with charges at depths of 15 m and 24 m. Little difference could be observed between the quality of the records, so for subsequent tests a depth of 15 m was considered to be adequate (Plate 24).

A charge comparison at SP687 (Plate 24) indicated that unit charges of 5 kg gave slightly better results than 3.5 kg charges. During further tests at SP693, SP687, and SP683 (Plates 25 to 27), with unit charges from 1 kg to 9 kg and total charges up to 64 kg, comparisons showed that the heavier unit charges and heavier total charges gave the better results.

The tests showed that a charge of 5 x 0.5 kg was sufficient to give an energy return greater than background noise level to 3.0 s reflection time and that larger charges gave an energy return to greater than 4.5 s. The S/N ratio increased appreciably with a charge size of about 5 x 4.5 kg and again increased during production shooting with a total charge of about 7 x 9 kg. The energy return with a total charge of about 45 kg was sufficient to maintain an input level of 3 mV to 10 mV over a background noise level of 10 to 30 microvolts to approximately 1.2 s reflection time.

Shothole pattern comparisons were made at a number of shot-points. At SP693, where a charge comparison was made, the results from a 5-hole pattern and a 3-hole pattern with about the same total

charge were also compared (Plate 25). The hole spacing was 15 m giving wavenumber cut-offs of 4.0 cycles/300 m and 6.7 cycles/300 m respectively with the geophone pattern of 24 geophones, 3 m apart in line giving about 4.2 cycles/300 m. The 5-hole pattern record showed more-continuous reflections of higher amplitude (Plate 25).

A comparison made with charges of about 23 kg in 5 holes 15 m apart in line and in 7 holes 12 m apart in line, giving wavenumber cut-offs of 4.0 cycles/300 m and 3.6 cycles/300 m respectively (Plate 26), indicated that the 7-hole pattern gave better results but with some deterioration in the quality of the shallow reflection data. The geophone patterns in these tests consisted of 48 geophones per trace, in 2 rows of 24 in line with rows 9 m apart and geophones 3 m apart giving a wavenumber cut-off of about 4.2 cycles/300 m.

Comparison tests were made at SP685 and SP687 (Plate 28). Records from shots at SP685 and SP687 with 5 holes 15 m apart in line were compared with records from shots at the same shot-points with an areal pattern of 18 holes in 3 rows of 6 holes in line with rows and holes 12 m apart, giving a wavenumber cut-off of 4.2 cycles/300 m. The charge depths were approximately 17 m and 5 m respectively for the two types of patterns. The results from the 5-hole pattern were fair, but those from the 18 hole pattern were poor, probably because of poor energy transmission at the shallow depth. Further tests were made with an increase in the number of geophones to 48 per trace, in two rows of 24 in line with rows 9 m apart and geophones 3 m apart. Patterns of 7 holes 12 m apart in line, with wavenumber cut-off of 3.6 cycles/300 m, were shot at SP685 and SP687; a pattern of 5 holes 15 m apart was shot at SP687; and a pattern of 10 holes was shot in 2 rows of 5 holes in line with rows 12 m apart and holes 15 m apart. The latter shot failed to yield any improvement in S/N ratio. However, a considerable improvement in record quality was noted with the increase in charge size, in number of geophones, and in number of holes for Records C, D, E, and F (Plate 28).

Shot-hole pattern comparison tests were made at SP691 and SP693 to compare the effect of wavenumber cut-off and number of holes in patterns. (Plate 29). The geophone pattern was 48 geophones per trace as for the previous test, with a wavenumber cut-off of 4.2 cycles/300 m. Patterns of 7 holes 12 m apart in line, 7 holes 15 m apart in line, and 9 holes 12 m apart in line, with wavenumber cut-offs of 3.6 cycles/300 m, 2.9 cycles/300 m and 2.8 cycles/300 m were compared. The tests indicated that the lower-wavenumber pattern yielded better results; the 9-hole pattern yielded slightly better results than the 7-hole pattern.

Geophone pattern comparison tests at SP687 between 24 geophones per trace, 3 m apart in line, and 48 geophones per trace, in 2 rows of 24 geophones in line, rows 9 m apart and geophones 3 m apart (Records D, F, E, and G Plate 26) indicated that the larger pattern gave better results.

Comparisons with patterns giving different wavenumber cut-offs were made at SP691 (Plate 30). Geophone patterns were 48 geophones per trace, in 2 rows of 24 geophones in line with rows 9 m apart and geophones 3 m and 5 m apart for respective shots giving wavenumber cut-offs of 4.2 cycles/300 m and 2.5 cycles/300 m. Tests were repeated for shot-hole patterns with a wavenumber cut-off of 2.8 cycles/300 m for 7-holes and 9-hole patterns. Although the pattern with the larger number of holes gave slightly better results, very little difference could be attributed to the different geophone patterns.

During production recording on Traverse GL2 additional wavenumber cut-off comparison tests were made using longer pattern lengths. The experimental work had shown that by reducing the wavenumber cut-off significant improvement in the S/N ratio could be achieved. It was feared that the ground mixing introduced by use of long patterns could be detrimental to record quality; thus for production recording, compromise wavenumber cut-offs of 4.2 cycles/300 m and 2.9 cycles/300 m were adopted for the geophone and shot-hole patterns respectively. After initial coverage of the traverse using a standard technique, SP675 to SP681 was reshot (Plate 31) with 7 holes 15 m apart in line and 48 geophones per trace in 2 rows of 24 in line, with rows about 9 m apart and geophones about 5 m apart and the geophone station interval reduced from 45 m to 34 m. This technique yielded significant improvement in record quality.

Production Recording. Production recordings were made on Traverses GL2 and GL3. The technique used to record on Traverse GL2 from SP671 to SP699 was derived from the results of the experimental recordings, and was as follows:

Spread Length	1097 m
Shothole Pattern	7 holes, 12 m apart in line Change 3 kg to 7 kg with total charge up to about 48 kg at 15-18 m
Geophone Pattern	48 geophones per trace, in 2 rows of 24 in line, with rows 9 m apart and geophones 3 m apart.

Fair-quality reflections were recorded on Traverse GL2 (Plate 32). Very shallow reflection events were strongly attenuated by using the long pattern; deeper events were of fair quality but not continuous along the entire traverse. The deepest continuous events was recorded at a time of about 2.2 s. The section from SP675 to SP681 which was reshot with longer patterns and shorter geophone station interval (Plates 31) showed an improvement in record quality, but time did not permit reshooting the entire traverse using this technique.

Traverse GL3 was shot using the same technique as that used for reshooting part of Traverse GL2 (Plate 33). Fair-quality results were obtained in the shallow part of the section, but no continuous deeper events were recorded.

Discussion of Results. Surface problems expected in seismic work were energy transmission problems, seismic noise problems, and difficulties in drilling.

The best energy transmission was obtained by placing charges at depths of at least 15 m. Total charges of about 45 kg per shot yielded reasonable results. Three types of noise were distinguished. Longitudinal noise was attenuated using spatial filters with a wavenumber cut-off of about 3 cycles/300 m. Transverse noise was attenuated by areal patterns of geophones and shot-holes; larger spacing between rows of shot-holes and geophones would probably have increased the attenuation. High-frequency shot-generated noise, which was probably caused by the cavernous nature of the limestone, was filtered by using electrical filters. The use of a large number of geophones also assisted in attenuating this noise, which was of a random nature. Despite reports of difficult drilling conditions in Gambier Limestone, drilling presented no major problems. The drilling logs on Traverse GL2 show hard flint beds up to 15 cm thick. The deepest hole (at SP689, to 64 m) did not drill through the Gambier Limestone. On Traverse GL3, rapid changes in near-surface conditions were found with varying thicknesses of unconsolidated sand, sandstone, clay, and limestone. No cavities large enough to cause circulation difficulties were encountered.

Conclusions

The following conclusions were reached as a result of the experimental and production seismic reflection work on Traverses GL2 and GL3:

- (1) A fairly high-effort technique, evolved from the experimental program, was necessary to give reasonable seismic reflection results. It was considered that further improvements could be achieved with more powerful spatial filters and more explosives.
- (2) The expected problems of energy transmission and seismic noise were overcome satisfactorily.
- (3) Drilling on the Gambier Limestone did not prove to be the major problem expected. Penetration rates of 15 m to 43 m per hour were achieved.
- (4) The seismic results were much better than those obtained previously by shot-hole methods and were comparable to those obtained on the 'Vibroseis' survey.

SAND DUNES PROJECT

Recent coastal sand dunes and consolidated fossil dunes form low ranges parallel to the coast to the south-southeast of Mount Gambier. These and areas of exposed Pleistocene sand dunes to the north of Mount Gambier have presented energy transmission problems and difficult drilling in seismic shot-hole surveys in the area.

Previous Seismic Information

Seismic traverses shot by the South Australian Department of Mines and contractors employed by the petroleum exploration licensees in the Gambier Sunklands for reconnaissance purposes gave poor results when shooting on sand dunes.

Vibroseis Survey, 1964. Experimental 'Vibroseis' recordings were made in areas of sand cover near Mount Gambier during a 2-week period in July and August 1964 (Seismograph Service Ltd, 1965; Moss, 1965).

Recordings were made initially along Traverse SD1 on the highway south of Tarpeena on the Mount Gambier to Penola road, south of a sand covered area. Fair-quality reflections showing slight south dip were obtained over the 1.6 km traverse to a reflection time of 1.0 s and poor quality reflection were obtained to a time of about 2.0 s. Source patterns were 122 m long and detector patterns were 122 m long by 61 m wide. The sweep frequency was 14 Hz to 57 Hz. The results were comparable to those obtained previously.

A noise test was recorded on the sand covered area to the north of Tarpeena on Traverse SD2 (Plates 2 and 34). Reflections of fair to poor quality were recorded with southerly dip to about 1.8 s reflection time using a transposed recording technique similar to that used initially on Traverse SD1 but with double the number of sweeps. It was concluded, from the limited amount of 'Vibroseis' work done, that reflections could be recorded on sand-covered areas using a high-multiplicity effort.

Program and Results

The sand dune problem was only superficially studied with the 'Vibroseis' survey. Since the results were only fair and little effort had been made to improve the results, it was considered that no extensive experimental program was justified on the comparison survey. Very little testing was done before deciding on a production technique on Traverse SD2. The work proposed along Traverse SD1 was abandoned because the traverse was covered with water for the duration of the survey in the area. Preliminary results on the comparison survey were presented by Jones (1966).

Uphole Survey (Traverse SD2, SP1101 1/3). The uphole survey was shot from a maximum hole depth of 27 m with 9-kg charges, with recordings made on a split spread of length 1073 m and 16 geophones per trace, 15 m apart in line. The results indicated vertical velocity in the sub-weathered layer of 2042 m/s, and a first-break velocity of 1859 m/s.

A study of uphole times and first-break times from production records indicated a weathering velocity of 457 m/s and a fairly consistent weathering depth of from 5 m to 6 m along the traverse. The record of best quality was obtained with a shooting depth of about 12 m.

Noise Analysis (Traverse SD2, SP1100). The noise test was recorded over spreads from 91 m to 1180 m from the shot-point with a trace spacing of 9 m and eight 14-Hz geophones bunched at each geophone station (Plate 35). The main noise events have velocities of 610 to 914 m/s and 2134 to 3048 m/s. Events numbered 2, 4, 5, 10, and 12 on the t/x and f/k, h/k, and h/f graphs (Plates 36 and 37) are most probably reflection events; events numbered 1, 8, and 15 may be reflection events, and other events numbered are noise events. A wavenumber cut-off of 3 to 4 cycles/300 m appeared to be satisfactory for attenuating the noise events.

Experimental Recordings. Limited experimental variation of shot-hole and geophone patterns was done.

Shot-hole pattern comparison tests were made on Traverse SD2 between SP1100 and SP1104. At SP1100, 3-hole patterns with holes 15 m apart and 5-hole patterns with holes 15 m apart giving wavenumber cut-offs of 6.7 and 4.0 cycles/300 m were compared (Plate 38). The geophone pattern for these tests was 16 geophones 5 m apart in line, giving a wavenumber cut-off of 3.8 cycles/300 m. At SP1101, 5 holes 15 m apart and 7 holes 15 m apart, giving wavenumber cut-offs at 4.0 and 2.9 cycles/300 m, with the same geophone pattern as for SP1100, were shot for comparison (Plate 38). The tests indicated a slight improvement in record quality when the wavenumber cut-off was decreased.

The test was designed to determine the most economical number of holes required to provide a reasonable S/N ratio, with a wavenumber cut-off of 2.9 cycles/300 m. Test shots were made to compare the results from using 7 holes 15 m apart with 5 holes 21 m apart, with 24 geophones per trace, 5 m apart 9 m line for both shots (Plate 39). Similar tests were made from SP1102 to SP1104 with 48 geophones per trace, in 3 rows of 16 geophones in line with rows 9 m apart and geophones 6 m apart (Plate 39). Very little difference could be seen in the results from the two shot-hole patterns.

Geophone pattern comparison tests were made on Traverse SD2 at SP1101 (Plate 40). The shot-hole pattern consisted of 7 holes 15 m apart in line. Comparison tests were made with 16 geophones per trace, 6 m apart in line, 48 geophones per trace, in 3 rows of 16 geophones in line, with rows 9 m apart and geophones 6 m apart, and 24 geophones per trace, 5 m apart in line, and 48 geophones per trace in 2 rows of 24 geophones in line, with rows 9 m apart and geophones 5 m apart. The wavenumber cut-offs for the in-line patterns were 3.1 and 2.5 cycles/300 m respectively. The records with 3 rows of 16 geophones per trace gave slightly better results.

Production Recording. The recording parameters used on Traverse SD2 were derived from the experimental tests. They were:

Shothole Pattern	5 holes, 21 m apart in line, charge 9 kg/hole at 12-14 m.
Geophone Pattern	48 geophones per trace, in 3 rows of 16 in line, with rows 9 m apart and geophones 6 m apart.

Fair-quality reflections were recorded on Traverse SD2 (Plate 41). High-amplitude continuous events were apparent to 1.0 s, but no continuous events were recorded below. The results from a $t: t$ analysis (Plate 42) indicated comparable velocity information to that obtained from Geltwood Beach No. 1 well (Bureau of Mineral Resources, 1965).

Discussion of Results

Difficulties in drilling, energy transmission and seismic noise were anticipated.

Drilling on this survey was not a problem and average penetration rates from 21 to 37 m per hour were obtained. In places holes collapsed during drilling, necessitating withdrawal of drill pipes and cleaning of holes. The drill logs indicated soft sand, sandy clay, and minor quantities of soft sandstone and friable limestone. Energy transmission was a problem. Although a medium-sized charge was sufficient to give an energy return above background noise level for several seconds, large charges were required to give a fair S/N ratio, and the largest charges used gave the best quality records. A total charge of 45 kg gave an input energy level of 3 microvolts to 10 mV down to about 1.0 s compared to a background noise level of 3 to 10 microvolts at the southern end of the traverse. The input level dropped when shooting northwards to approximately 300 microvolts at SP1113. The shot-points from SP1109 to SP1113 were in areas of soft sand. SP1112 and SP1113 were reshot with a total charge of 136 kg, giving a record quality only comparable with the rest of the section shot. Noise events recorded were satisfactorily attenuated using patterns to give a wavenumber cut-off of approximately 3 cycles/300 m.

Conclusions

Little experimental work was done on Traverse SD2, and only generalized conclusions could be reached on the seismic survey results.

- (1) A fairly high-effort technique was required to give reflection results of reasonable quality. No claim is made that the technique used for the production work is optimum; further experiments would have to be undertaken for detailed seismic work in the sand dunes area.
- (2) The seismic results were of better quality than previous shot-hole seismic survey results and were comparable to those obtained on the 'Vibroseis' survey.

3. SYDNEY BASIN SURVEY

INTRODUCTION

The experimental seismic surveys in the Sydney Basin were made between mid-September and mid-November 1965 (Schwing, 1966).

Previous seismic work in the Sydney Basin was restricted generally to areas with no Triassic Hawkesbury Sandstone outcrops. Areas covered by this formation were classified as problem areas because of the rugged nature of the outcrops, hard drilling, and the generally poor quality of seismic records obtained previously. The experimental survey was made along traverses covered by the 'Vibroseis' survey in 1964 (Plate 44).

GEOLOGY

The Sydney Basin (Plate 43) is bounded on the west and the south-west by lower and middle Palaeozoic sediments intruded by granites. To the northwest it is cut off from the outcropping Carboniferous sediments by the Hunter Fault. In the east the continuation of the basin under the Pacific Ocean was unknown.

The main stratigraphic sequence in the basin is summarized in Table 2.

TABLE 2: STRATIGRAPHY OF THE SYDNEY BASIN

Age	Group Formation	Lithology	Maximum thickness	
			Southeast	Central north
Triassic	Wianamatta Gp	Shale and sandstone	244 m	244 m
	Hawkesbury Sandstone	Massive quartz sandstone	274 m	274 m
	Narrabeen Gp		760 m	760 m
Permian	Upper Coal Measures		305 m	1676 m
	Gerringong Volcanics		325 m	-
	Upper Marine		1067 m	1524 m
	Lower Coal Measures		41 m	305 m
	Lower Marine		-	1829 m
	Upper Kuttung Volcanics		-	1311 m
	Lower Kuttung Volcanics		-	671 m

The dominant outcropping formations in the central and northern parts of the basin are the Hawkesbury Sandstone and the Narrabeen Group. The lithology of the Hawkesbury Sandstone, a hard massive quartzite sandstone, is similar in places to that of the Narrabeen Group.

HAWKESBURY SANDSTONE PROJECT

Problems inherent in the areas where the Hawkesbury Sandstone crops out are seismic energy transmission, variations in the weathered layer, hard drilling, and in accessibility for seismic surveys.

The Hawkesbury Sandstone has a fairly high velocity, making penetration of seismic energy to deeper formations difficult. Minor faulting in the section also causes dispersion of energy. The variable weathering of the highly eroded surface makes it difficult to obtain reliable static corrections. Drilling is difficult on the hard surface. Seismic traversing is difficult, being limited to ridges of sandstone in the highly eroded surface.

Previous Seismic Information

BMR made an experimental seismic survey in the Sydney Basin in 1957 (Robertson, 1958). The applicability of the seismic reflection method was tested in areas with various outcropping formations, although no complex techniques were applied. Seismic work was done on the Triassic Wianamatta Shale and Hawkesbury Sandstone in the central part of the basin and on the Permian Coal Measures in the Hunter River Valley near Singleton.

Fair-quality results were obtained on the Wianamatta Shale and the Coal Measures but poor results were obtained in test areas on the Hawkesbury Sandstone. At Dural, some indications of sedimentary structure to about 1200 m were obtained from shooting on Hawkesbury Sandstone with 10 geophones per trace 7 m apart in line and single holes to depths down to 61 m with charges of about 11 kg.

A considerable number of seismic surveys have been made in the basin since 1957, mainly in areas with little or no Hawkesbury Sandstone on the surface. Fair-quality results were obtained, in the period up to 1964, with 12 geophones per trace, up to 6 m apart in line, and with single holes to 61 m or shallow 9-hole diamond patterns. Only poor results were obtained in some Hawkesbury Sandstone areas despite considerable testing with different size of charge, varying the number and spacing of geophones and shot holes and depths of holes. It was considered that the poor-reflection areas could be highly faulted. Other work on Hawkesbury Sandstone areas provided useful shallow information but no usable results below about 1830 m.

'Vibroseis' Survey, 1964. The experimental 'Vibroseis' survey was made on Hawkesbury Sandstone outcrops in the Kulnura and Grassey Hills areas during a 6-week period from August to October 1964 (Seismograph Service Ltd, 1965; Moss, 1965).

On Traverse HS1, approximately 5 km south of Kulnura No. 1 bore, noise tests were recorded and detailed experiments were made with different source geophone offsets, sweep frequencies, number of sweeps, and vibrator and geophone patterns. The most troublesome event recorded on the noise tests was the first break, of high velocity and large amplitude. A transposed technique with 183 m long vibrator patterns and 183 m long by 60 m wide geophone patterns and a sweep frequency from 10 Hz to 40 Hz was adapted for production recording.

Good-quality reflections were recorded between 0.5 and 0.7 s and the quality of deeper seismic information at a time of about 1.7 s was improved by increasing the lengths of the source and detector patterns to 300 m and increasing the source-geophone offsets. The quality of the deeper reflection events was improved at the cost of attenuating shallower reflection events.

The techniques found to be applicable for work on Traverse HS1 were used for recording on Traverse HS2 along a winding road past Kulnura No. 1 bore. Fair-quality reflection events were recorded to approximately 1.4 s, and the Kulnura Anticline was shown to extend in low relief through the section. On both Traverses HS1 and HS2, appropriate equipment electrical filters and the 10 Hz to 40 Hz sweep attenuated 50-Hz pick-up, which on previous surveys had been extremely troublesome and had completely swamped the latter part of the seismic records, beyond 0.7 s.

Fair-quality reflections were obtained on Traverses HS3 and HS4 at times to 1.0 s and poorer-quality reflections to 1.6 s. The reflection quality deteriorated towards the eastern end of Traverse HS4, which was located on a narrow Hawkesbury Sandstone ridge with steep gorges on either side.

The 'Vibroseis' results on Hawkesbury Sandstone showed some improvement over previous results from shot-hole work, and this was attributed to the use of longer source and detector patterns and the choice of a 10 Hz to 40 Hz sweep frequency.

Velocity Information. Information on vertical velocities in the Sydney Basin was obtained from sonic logs, $t:\Delta t$ analyses, and expanded spreads. The

velocity relationship in the Permian section from the sonic logs from the Loder No. 1 and East Maitland No. 1 wells, is $V_i = 3658 + 0.6 d$. In the northern part of the basin, a constant vertical velocity $V_a = 3962$ m/s, derived from $t-t$ analyses, was used for reflection corrections. At Woronora and Camden in the south, a constant velocity $V_a = 3658$ m/s was found to be reasonable for the section to the top of the Upper Marine sequence. The results from the 'Vibroseis' survey were interpreted using the velocity function from East Maitland No. 1 well.

Program and Results

The seismic program was designed to record along Traverses HS1, HS2, HS3, and HS4 (Plates 44 and 45) and for the 'Vibroseis' survey. The program consisted of preliminary testing to measure physical conditions in the test areas, experimental recording to study the effects of varying recording parameters, and production recording (Schwing, 1966).

Uphole Survey (Traverse HS1, SP1409A). Charges up to 18 kg were shot from depths of 73 m to the surface. An 805 m long spread was laid on one side of the shot-point with 48 geophones per trace in 2 rows of 24 geophones in line, with rows 8 m apart and geophones 6 m apart. This pattern was suggested from the results of previous surveys, to eliminate some noise. Drilling was moderately difficult in a continuous sandstone sequence with hard and soft bands of various thicknesses.

The results (Plate 46) indicated velocities of 305 m/s to a depth of 3 m, 1524 m/s to 24 m, 2530 m/s to 47 m, and 3810 m/s to 73 m. The energy level, as indicated on the LLI curve, drops rapidly from 10 mV at the first arrivals to 30 microvolts at about 1.2 s. Some signal could be observed at about 0.5 s to 0.6 s and 0.9 s. For shots above and below 32 m to 35 m (the depth of a thin band of very hard sandstone) record quality deteriorated. In the area of the uphole survey the optimum shooting depth appeared to be critical, at about 32 m. The reflection records indicate a predominance of low-frequency events, 50-Hz pick-up at input levels less than 30 microvolts and a high background noise level.

Noise Analysis (Traverse HS1, SP1409B; Traverse HS2, SP1487B). Charge of 18 kg were shot at a depth of 24 m into spreads laid out to 960 m. The trace interval was 9 m. Noise tests were recorded twice, with four 4.5-Hz geophones bunched per trace and recording filters 0 to K120 and with eight 14-Hz geophones bunched per trace and recording filters 0 to K92 and prefilters 18 Hz, 12 dB per octave. Amplifier gains were increased with distance. Transverse noise spreads were recorded, with trace intervals of

3.8 m at distances of 146 m and 402 m from the shot-point. Record sections for the noise tests (Plates 47,48,51, and 52) were made using AGC on playback.

On Traverse HS1 (Plate 49) the first-break velocity on the noise test was 3749 m/s. Three types of noise were observed: events numbered 6,7, and 8 with a velocity of about 1829 m/s and frequency of about 30 Hz; a group of low-frequency and high-amplitude events numbered 1, 2, 1A, and 2A with velocities averaging about 1067 m/s and a frequency of about 10 Hz; and very low-velocity noise events numbered 3 and 4 with velocities of about 396 to 518 m/s and a frequency of about 20 Hz. Event No. 9, with an apparent velocity of 5578 m/s and a frequency of 36 Hz, was tentatively identified as a seismic reflection event, despite its low normal moveout. The event was observed at a distance of 610 to 732 m with a wavenumber of 2 cycles/300 m.

Comparison between the recordings made using 4.5-Hz and 14-Hz geophones indicated that approximately 50 percent of the events were recorded on both (Plates 47 and 48). The use of 14-Hz geophones and pre-filters resulted in a shift of spectra towards higher frequencies and wavenumbers. A spatial filter with a wavenumber cut-off of about 3.5 cycles/300 m appeared to give adequate attenuation of noise events with the 14-Hz geophones. However, the fact that lower-frequency components were attenuated to the extent that they could not be visually picked on the noise test records with the 14-Hz geophones, did not mean that they could not influence results on normal recordings. Previous experience suggested that very long source and detector patterns would be necessary, so experimental recordings were made using patterns with a wavenumber cut-off of 2 cycles/300 m, a powerful spatial filter which could under some circumstances adversely affect the reflected signal.

Some transverse noise was detected, but it was not as troublesome as would be expected on seismic traverses along the ridges. Wavenumbers of 9 and 18 cycles/300 m were calculated for the transverse noise events.

On Traverse HS2 (Plate 53), a low-frequency event of velocity 1219 m/s and frequency 10-Hz was the main event recorded, together with an event of velocity 1981 m/s and frequency 60 Hz. No signal events were apparent and no significant transverse noise events were recorded. The wavenumber spectrum (Plate 54) again indicated that a wavenumber cut-off of about 2.5 cycles/300 m was desirable.

Analysis of the noise test results and the results of previous seismic work in the area indicated a number of preliminary conclusions on seismic work on the Hawkesbury Sandstone outcrops. The depth of the charges appeared to be critical; transmission of energy appeared to be a major problem and large charges were expected; long shot-hole and geophone patterns with wavenumbers of about 2.5 cycles/300 m appeared necessary; transverse noise did not appear to be a problem generally but could be a problem in recording along ridges; 50-Hz pick-up was strong and notch filters should be used; and the background noise level was high. To overcome the background noise level, caused mainly by wind in the surrounding scrub, 20 dB ultimate sensitivity would be required normally; a large number of geophones would also assist in reducing random noise.

Experimental Recordings. The main experimental work was on Traverse HS1 (Plate 45) where the experimental 'Vibrosesi' work had been done. Experiments were conducted wherever possible under similar conditions, varying one parameter at a time. In some cases comparison tests had to be made at different shot-points because of fracturing of shot-holes by large charges. Discussion of some experimental work done during the production recording is included.

The recording instrument settings, selected from experience gained from the previous shot-hole and the 'Vibroseis' surveys and from the results of the uphole survey, were as follows:

Amplifier Filters	Recording 0-K92 Playback K20-K60
Notch Filter	50 Hz
AGC	Medium
Presuppression	-60 dB
Ultimate Sensitivity	-10 dB to -30 dB
Pre-filter	21 Hz, 24 dB per octave
LLI	10 mV input full deflection

Attenuation of -20 dB was used mostly, but on rare occasions with strong winds -30 dB was used. Operations were suspended when a higher attenuation became necessary. Initially prefilters of 18-Hz, 20 dB per octave, were used but a comparison made at SP1408A indicated that low-frequency noise components were attenuated using the selected prefilter.

A spread length and offset comparison test was made. The traverse was initially surveyed with a spread length of 402 m corresponding to the 'Vibroseis' spread length, but this proved to be unsatisfactory because reasonable production could not be obtained economically with such a short spread and because of the inherent dangers of attenuating shallow reflections by ground mixing with geophone patterns of 152 m. The results from an 805-m spread recorded at SP1408 showed some discontinuity for the end traces of the shallow reflection, but the seismic information was not noticeably deteriorated. However, it was a longer spread than was permissible for the use of 152 m long geophone patterns for recording shallow reflections. A spread length of 537 m was selected as being the most suitable compromise between 402 m and 805 m long spreads, and ground mixing was limited. Shot-point positions on the seismic traverses were resurveyed at this interval.

The centre traces on the monitor records showed strong interference from shot-hole noise. The offset was varied from 0 to 402 m with a spread length of 402 m to determine how much improvement could be achieved in the S/N ratio on the centre traces. Although an improvement was found (Schwing, 1966) no further tests were made with offset shooting because shot-hole noise was filtered adequately on playback and offset shooting slowed down operations.

Charge comparison tests were made at SP1408 and SP1407. Initially tests were made at SP1408A, comparing the results using total charges of 163 kg with 123 kg, in 9 holes of depth 24 m to 27 m, 15 m apart in line. The heavier charge yielded substantially better results, indicating that the use of large charges was important for input of energy. Further tests at SP1408 with shots of 159 kg and 222 kg, in 7 holes of depth 28 to 32 m and 31 to 37 m respectively, supported the initial conclusion. There was little energy return and the quality of the records was poor. The LLI curve indicated an input of 1 mV and its level at 1.5 s corresponded to 30 microvolts.

Further tests of charge sizes were made during the survey, sometimes under less than ideal conditions. At SP1407 comparisons made with 286 kg and 227 kg charges gave slightly better results with the heavier charge but results were inconclusive since the number of shot-holes was varied from 7 to 9. Charge sizes were varied for a number of reasons for production shooting on the traverses.

Geophone pattern comparison tests were made at SP1408 and SP1409. Normally 24 geophones per trace, 6 m apart in line, were used to attenuate noise below 2 cycles/300 m. The number of rows of geophones parallel to the traverse and the spacing of rows were varied during experimental shooting. Previous shot-hole seismic surveys was geophone patterns of 24

geophones per trace, 4 m apart in line, gave a wavenumber cut-off of 3.1 cycles/300 m compared with 2.1 cycles/300 m for the same number of geophones 6 m apart.

An experiment was made to determine if an increase in the number of geophones would result in attenuation of the background noise. 96 geophones per trace in 4 rows of 24 in line with rows 15 m apart were compared in tests with 48 geophones in 2 rows of 24 in line. 12-trace records recorded at SP1408 and SP1409 (Plate 55) indicated that the S/N could be improved using 96 geophones per trace but not sufficiently to warrant the use of the increased number of geophones for production work. The improvement in record quality with the increased number of geophones per trace was considered to be partly because of the attenuation of transverse noise as well as random noise.

A number of in-line and diamond-shaped shot-hole pattern comparison tests were made (Plate 56). Initially the results from patterns with charges in 9 holes 15 m apart in line, 7 holes 15 m apart in line, 5 holes 31 m apart in line, and 10 holes in 2 rows of 5 holes in line with rows and holes 31 m apart were compared. Shot-hole depths averaged 27 m and the charges were 159 kg. The wavenumber cut-offs of the respective patterns were 2.2, 2.9, 1.9 and 1.9 cycles/300 m. The energy level was low and the noise level was high. It appeared that the quality of the data was improved with the use of long patterns and larger number of holes.

The test, repeated at SP1408, Test 4B (Plate 56) with 7 holes 15 m apart in line and 10 holes in 2 rows of 5 holes in line with rows 31 m apart and holes 21 m apart, indicated that the 7-hole pattern of greater length gave better results. At SP1407, Test 4C (Plate 56), the results of tests with a pattern of 7 holes 15 m apart in line, with a charge of 227 kg, compared with a pattern of 9 holes 15 m apart in line, with a charge of 286 kg, indicated that the 9-hole pattern gave better results.

At SP1411, Test 4D (Plate 56), a comparison was made using 7 holes 21 m apart in line, and 14 holes in 2 rows of 7 in line with rows 31 m apart and holes 21 m apart, with similar charges of 222 kg. The 14-hole pattern gave the best results, probably because of transverse and random noise cancellation. Diamond-shaped patterns were compared at SP1410, Test 4E (Plate 56), with 9 holes 21 m apart, 16 holes 21 m apart, and 36 holes 12 m apart. Charges of 163 kg were fired at depths of 28 to 32 m for the 9-hole and 16-hole patterns and 3 to 5 m for the 36-hole patterns. The 36-hole pattern gave the poorest result and the 16-hole pattern gave the best results.

The diamond patterns at SP1410 yielded poorer results than the in-line patterns, probably because of less efficient in-line filtering of longitudinal noise events. The wavenumber cut-offs of the diamond patterns were 6.7 and 5.0 cycles/300 m.

It was not always possible to shoot large hole patterns because of field conditions. On Traverse HS1 at SP1413 2/3, 13 holes 11 m apart in-line were shot to determine if this would be a satisfactory alternative to using 2 rows of 7 holes. This alternative shothole pattern arrangement gave results of similar quality and was used on Traverse HS4, where areal patterns could not be used because of thick bush. It was concluded that large charges should be distributed in a large number of shot-holes, giving less shattering of the hard sandstone and better coupling and energy transmission.

Production Recording. Production recording was done on Traverses HS1, HS2, HS3, and HS4 (Plate 45) after experimental recording on Traverse HS1. A high-effort technique was used initially to obtain the best results possible, but because of a strain on the manpower and equipment resources available a compromise technique was adopted between the high-effort technique and the low-effort techniques used previously.

On Traverse HS1 the best records from the experimental and production work were used to produce the record section on Plate 57. The geophone pattern consisted of 48 geophones in 2 rows of 24 in line, with rows 15 m apart and geophones 6 m apart, the shot-hole pattern used was varied, and charges of 227 kg were fired at depths of about 31 m. Continuous reflection events fair too good quality were recorded at about 0.5 s and between 1.0 and 1.2 s and some deeper discontinuous events could be observed. The importance of solid tamping could be seen from the shot at SP1415 (Plate 45) for which 6 holes of the 14-hole pattern blew out with subsequent poor energy transmission and poor record quality. The poor quality of deep reflections at SP1404 1/3 and SP1405 2/3 was due to poor energy transmission by charges placed in unconsolidated material.

A low-effort technique was chosen for production work on Traverse HS2 along a winding road on a narrow Hawkesbury Sandstone ridge. The geophone pattern consisted of 24 geophones 6 m apart in line, the shot-hole pattern was 7 holes 21 m apart in line, and charges of 95 kg were fired at depths of 18 m. Record quality (Plate 58) was poor. The shallow reflection was poorer than on Traverse HS1 and discontinuous; no deeper reflections could be followed over more than one or two shot-point intervals along the traverse. The results suggested that heavier charges would be required to improve the S/N ratio, and areal arrays of geophones and shotholes would be necessary to filter transverse noise.

On Traverse HS3 the Hawkesbury Sandstone was covered with alluvium and drilling was reasonable. Recording techniques similar to those used on Traverse HS2 yielded better results than on Traverse HS2 (Plate 59), probably because the Hawkesbury Sandstone was softer (as seen from the drilling rates, Appendix 4) and energy transmission was better. The techniques used did not give consistently good results, however, since there was a definite deterioration of quality to the north of the traverse about SP1606.

Traverse HS4 was located along a ridge of only fair access; rugged topography and fairly thick bush made it difficult to lay geophone patterns and drill shothole patterns. Since the setting was typical for most seismic work on Hawkesbury Sandstone in the Sydney Basin, it was decided to use the high-effort technique developed on Traverse HS1. 48 geophones per trace in 2 rows of 24 in line, with rows 15 m apart and geophones 6 m apart, were laid wherever possible; 13 holes 11 m apart in line were used, and charges of 222 kg were fired at depths of 15 to 18 m. Fair-quality continuous reflection events were recorded at times of 0.5, 0.8, and 1.6 s (Plate 60), with a degradation of record quality to the east of SP1704, where the ridge narrowed.

Discussion of Results. The main problems expected in obtaining seismic information on Hawkesbury Sandstone outcrops were energy transmission, variable weathering, difficult drilling, inaccessibility and seismic noise problems.

Energy transmission in the Hawkesbury Sandstone areas was poor. Heavy charges, placed in unweathered rock and solidly tamped, were necessary to give consistent fair-quality seismic results. Charges of at least 159 kg were necessary. In the area tested, the optimum shooting depth was about 31 m. The amount of energy return decreased significantly when holes blew out. A large number of small charges gave better results than a small number of large charges. For patterns of more than 9 holes, the hole depths were reduced to 18 m as a compromise because it was uneconomical to drill large numbers of holes to 31 m. Variable weathering did not prove to be a major problem, particularly with the averaging affects of large numbers of geophones and shot-holes. Drilling conditions were variable, but average penetration rates of approximately 18 m per hour on Traverse HS1 and more than 30 m per hour on other traverses using the Mayhew 1000 drilling rig were considered reasonable. Inaccessibility remained a problem, and no attempt was made to shoot seismic traverses on Hawkesbury Sandstone areas with no existing tracks.

Three types of noise were identified. Longitudinal noise was attenuated sufficiently by patterns of geophones and shot-holes with a wavenumber cut-off of 2.0 to 2.5 cycles/300 m. It was concluded from the tests that 9-hole shot patterns with holes 15 m apart, or 7-hole shot patterns with holes 21 m apart, would be required to give the necessary wavenumber cut-off. The low-frequency longitudinal surface waves recorded on the noise tests were attenuated on production recording using the pre-filters with a frequency cut-off of 21 Hz and a slope of 24 dB per octave. Transverse noise was a problem, particularly when shooting on Hawkesbury Sandstone ridges. It was attenuated by using areal patterns with 2 rows of geophones 15 m apart and 2 rows of shot-points 31 m apart. Background noise attributed to the effect of wind and trees was attenuated by using a large number of geophones in the patterns. 50-Hz pick-up noise from numerous high-voltage lines throughout the area was attenuated using a 50-Hz notch filter.

The best seismic reflection results were obtained on Traverse HS1, on which a high-effort technique was used. A low-effort technique on Traverse HS2 yielded poor results. The main differences in techniques used on Traverse HS2 compared with those used on Traverse HS1 were the use of single rows of holes and geophones, giving no filtering of transverse noise, 95 kg charges instead of 152 kg charges, and shooting depths of 18 m instead of 31 m.

The same low-effort technique was used on Traverse HS3 and gave fair quality results. This was probably because the sandstone was less consolidated on this traverse; also the traverse lay on a plain and consequently there was less transverse noise. Degradation of quality to the north of Traverse HS3 suggested that the technique was of too low effort to give results of consistently fair quality even in that area and that a high-effort technique was probably better generally.

The high-effort technique from Traverse HS1 was modified for use in the rugged ridge area on Traverse HS4. In-line patterns were used. Degradation of record quality where the ridge narrowed was probably due largely to transverse noise.

The record section from Transverse HS1 (Plate 57) indicates a reflection event with little dip at 0.5 to 0.6 s along the traverse. This event is probably from the Upper Coal Measures at the top of the Upper Permian section. There is evidence of deeper discontinuous reflection events to more than 2.0 s reflection time. The deeper events exhibit slight south dip. On

Traverse HS2 (Plate 58) the event at about 0.5 s is still discernible. The reflecting horizon associated with this event is at a depth of about 980 m. Deeper, discontinuous, poor-quality events were recorded. The most continuous of these is at a reflection time of about 1.45 s under SP1486 from a reflecting horizon at about 3350 m. Reflection events of fair to poor quality were recorded at similar times on Traverses HS3 and HS4 (Plates 59 and 60).

Conclusions

The main conclusions reached as a result of the experimental and production seismic reflection work on Hawkesbury Sandstone outcrops were as follows:

- (1) The properties of the Hawkesbury Sandstone vary throughout the basin and preliminary testing is necessary, in each area to be surveyed, before adopting a particular technique.
- (2) Energy transmission is a major problem and shooting needs to be done under controlled conditions. Optimum shot-hole depths must be used and charges tamped solidly. Total charges required in poor seismic areas should be about 200 kg, but heavy unit charges must be avoided to prevent loss of energy by fracturing of the formation. In the Kulnura area, charges had to be placed in hard rocks for efficient energy transmission whereas in the Grassy Hills area, where the Hawkesbury Sandstone is less consolidated, the energy transmission characteristics were better even though the charge was not in hard rocks.
- (3) Long geophone and shot-hole patterns were required to attenuate longitudinal noise, and the use of a pre-filter was necessary to avoid saturation of the early stages of amplification by the high-amplitude low-frequency noise. Transverse noise was attenuated by areal patterns; background noise, mainly caused by wind and trees, was attenuated by a large number of geophones, up to 48 geophones per trace in some cases; and a 50-Hz notch filter was used to attenuate pick-up from high-voltage lines.
- (4) A seismic reflection event of fair to poor quality was recorded at a time of approximately 0.5 s with little or no dip on all traverses. Poorer information was recorded from the section below. The seismic survey results, although comparable in quality to the 'Vibroseis' results, did not provide reliable information on the deeper part of the sedimentary section in the Sydney Basin.

4. CONCLUSIONS

The experimental seismic survey, using explosives, to obtain valid comparisons with the results of the 'Vibroiseis' survey in the Otway and Sydney Basins, was successful generally in providing seismic reflection data of at least equivalent quality to those of the 'Vibroiseis' survey. The time spent on experimental work and the number of experimental recordings made was approximately the same on both surveys and production recordings were made along common traverses on both surveys. The seismic program had to be tailored to local conditions; it was not always possible to obtain comparison recordings at common shot-prints, but the results of most tests appeared conclusive. Inclement weather in the Otway Basin during 1965 disrupted the survey and part of the work had to be deferred to 1966.

In most areas little experimental seismic work other than the 'Vibroiseis' survey had been done previously, and it was necessary to make a number of experiments to determine recording parameters including best shooting depths, charge sizes, geophone and shot-hole patterns, and instrument settings. The problems expected in most areas included energy transmission, variations in weathering, difficult drilling, and seismic noise but in some of these proved to be only minor ones. The experimental seismic survey had the advantage of prior knowledge of some of the remaining problems from the 'Vibroiseis' survey results prior to the comparison survey. This influenced the course of the experiments slightly but an attempt was made to conduct the program without being prejudiced by the 'Vibroiseis' results.

In the volcanics area energy transmission was satisfactory with medium-sized charges up to 64 kg placed in hard basalt; drilling conditions were varied, but drilling rates of up to 37 m/hr were considered satisfactory and variations in weathering and lateral vertical velocity variations in the section were not significant. The main problem affecting the seismic results was longitudinal and transverse noise. Shot-hole and detector patterns had to be designed to attenuate longitudinal noise substantially without significant deterioration of shallow reflection events. A high-effort technique was necessary for recordings in the Gambier Limestone area. Drilling conditions varied, but drilling rates of up to 43 m/hr were considered to be satisfactory. Random and transverse noise problems were the most significant. Large numbers of geophones placed in areal arrays were necessary. It was concluded that results of better quality would have been obtained with charges larger than the 45 kg charges used and longer and larger areal patterns of geophones and shot-holes. Some experimental work was done on the sand dunes area. Drilling was not difficult apart from problems with holes collapsing. Weathering variations were not significant. Energy transmission

was a problem and large charges of about 140 kg were necessary. Large numbers of geophones and long geophone patterns were necessary to attenuate noise events satisfactorily. In the Hawkesbury Sandstone area, energy transmission was poor; charges up to 227 kg were necessary, with the charges split into small unit charges in a large number of well tamped holes. Weathering variations were not significant and drilling conditions were satisfactory with drilling rates of 18 to 30 m/hr. Noise was a major problem. Longitudinal noise was attenuated by using long patterns that gave some ground mixing, and 50-Hz pick-up noise was attenuated with a notch filter. However, it was not always possible to lay areal arrays to effectively attenuate transverse noise, which was particularly troublesome when recording along narrow Hawkesbury Sandstone ridges. Access is still difficult to large areas covered by Hawkesbury Sandstone.

The seismic results obtained by the experimental seismic survey using explosives were comparable in quality to those obtained during the 'Vibroiseis' survey and were of better quality than those obtained in the test areas previously. Variation of recording parameters on the experimental survey was more difficult than on the 'Vibroiseis' survey. The experimental survey had a clear advantage over the 'Vibroiseis' survey in placing the explosive charges in consolidated rock below the weathered layer. The 'Vibroiseis' survey had some advantages in the use of controlled sweep frequencies, the use of cross-correlation techniques to provide sharp cut-off filters and to discriminate against random noise, and the ease with which a high multiplicity of vibrator points and geophones could be used for relatively low cost.

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Mineral Resources, Geology and Geophysics. Bur. Miner. Resour. Aust.
Rec. 1965/198 (unpubl.).

SMITH, C.B., 1963 - The 'Vibroseis' system - a practical field tool. Aust.
Oil. Gas J., 10 (1), 24-31.

APPENDIX 1
STAFF AND EQUIPMENT

Staff

Supervisor	E.H. Schwing (I.F.P.)
Party Leader	J.S. Raitt (1965) B.F. Jones (1966)
Geophysicist	B.F. Jones
Surveyors (from the Department of the Interior)	P. Pullinen (for Otway Basin Projects) N. Pesavento (for Sydney Basin Projects)
Observer	G.S. Jennings
Shooter	R.D.E. Cherry
Toolpusher	K. Suehle (P.T. 1965), B. Findlay (P.T. 1965-66)
Drillers	J. Keunen W. Whitburn
Drill Assistants	L.A. Keast A. Murphy (1965), E. Lodwick (1966)
Mechanic	E. McIntosh
Clerk	J.G. Terpstra
Field Hands	10

Equipment

Seismic Amplifiers	TI 7000 B
Oscillograph	SIE VT-6
Magnetic Recorders	ETL DS7-7 SIE PMR-20
Programmed Gain Control Units	SIE GCU-3EC
Prefilters	CGG
Geophones	HS-J, 14-Hz ETL EVS-8V, 4.5 Hz
Cables	Vector 549 m and 402 m

Drilling rigs	Mayhew 1000 (Otway Basin 1965, 1; Sydney Basin 1965, 2; Otway Basin 1966, 2)
	Carey (Otway Basin 1965, 2; Sydney Basin 1965, 1; Otway Basin 1966, 1)
	Failing (Contract rig in 1965)
Water tankers	Bedford RHLC (3)
Recording truck	International AB-120
Shooting truck	Bedford RHLC
Workshop truck	Bedford RHLC
Flat top	Bedford RHLC
Line vehicles	Landrover, L.W.B. (4)
Personnel vehicles	Landrover, Stn Wgn"
General purpose vehicle	International AB-120

Explosives, workshop, and general purpose trailers completed the party's mobile equipment.

APPENDIX 2
OPERATIONAL STATISTICS - VOLCANICS PROJECT

(Distances and weights were converted to metric units after the survey)

Sedimentary Basin	Otway Basin			
Survey area	Hamilton, Victoria			
Survey commenced	21 April 1965	21 Feb 1966	9 Mar 1966	
Drilling commenced	22 April	21 Feb	9 Mar	
Recording commenced	22 April	22 Feb	11 Mar	
Survey completed	19 June	25 Feb	21 Mar	
Traverses	<u>V2</u>	<u>V3</u>		
Total traverse length (km)	9.3	3.7		
Datum level for corrections (m)	183	122		
Weathering velocity (m/s)	549	914		
Sub-weathering velocity (m/s)	3048	3048		
Static correction method	Uphole times, first-break analyses			
Velocity function(m/s)	$V_i = 2185 + 0.65 d$			
Derivation of velocity function	t:Δt analysis			
Total depth drilled (m)	10869	4526		
Total number of holes drilled	357	163		
Total number of drilling field hours	993.5	340		
Total drilling time (hr)	687.25	185.25		
Average penetration rate (m/hr)	(1965)	(1966)	(1965)	(1966)
Carey	8.7	6.7	16.9	27.5
Mayhew	15.6	18.0	21.3	26.3
Failing	23.9		27.2	
Total number of recording field hours	387.5		141.5	

Total recording time (hr)

Experimental	158.75	44.5
--------------	--------	------

Production	116.5	56.5
------------	-------	------

Total number of profiles

Experimental	160	51
--------------	-----	----

Production	77	16
------------	----	----

Total explosives used (kg)

4.54 kg charges	1932	1134
-----------------	------	------

2.27 kg charges	3139	414
-----------------	------	-----

Total deternators used

31 m length	577	250
-------------	-----	-----

9 m length	73	19
------------	----	----

APPENDIX 3
OPERATIONAL STATISTICS - GAMBIER LIMESTONE AND
SAND DUNES PROJECTS

(Distances and weights were converted to metric units after the survey)

Sedimentary basin	Otway Basin			
Survey area	Mount Gambier, SA			
Survey commenced	18 June 1965	28 Feb 1966	19 Mar 1966	
Drilling commenced	21 June	28 Feb	19 Mar	
Recording commenced	23 June	1 Mar	22 Mar	
Survey completed	1 Sept	10 Mar	22 Mar	
Traverses	<u>GL2</u>	<u>GL3</u>	<u>SD2</u>	
Total traverse length (km)	8.0	1.6	5.6	
Datum level for corrections (m)	0	61	61	
Weathering velocity (m/s)	610	610	457	
Sub-weathering velocity (m/s)	2134	1829	2042	
Static correction method	Uphole times, first-break analyses			
Velocity function (m/s)	$V_i = 2134 + 0.55 d$			
Derivation of velocity function	t: Δt analysis			
Total depth drilled (m)	12030	948	3007	
Total number of holes drilled	656	51	185	
Total number of drilling field hours	800.75	91.25	302.5	
Total drilling time (hr)	385.5	41.25	101.75	
Average penetration rate (m/hr)	(1965)	(1966)		
Carey	22.9	21.0	14.2	28.9
Mayhew	28.1	31.6	20.4	20.8
Failing	42.7	-	29.4	37.2
Total number of recording field hours	349	23.75	131	

Total recording time (hr)

Experimental	146	-	44.5
Production	163	16.25	36.5

Total number of profiles

Experimental	164	-	53
Production	86	10	30

Total explosives used (kg)

4.54 kg charges	2563	91	853
2.27 kg charges	3208	308	857

Total detonators used

31 m length	898	44	157
9 m length	18	-	32

APPENDIX 4

OPERATIONAL STATISTICS - HAWKESBURY SANDSTONE PROJECT

(Distances and weights were converted to metric units after the survey)

Sedimentary basin	Sydney Basin			
Survey area	Gosford, NSW			
Survey commenced	9 September 1965			
Drilling commenced	9 September 1965			
Recording commenced	13 September 1965			
Survey completed	19 November 1965			
Traverses	<u>HS1</u>	<u>HS2</u>	<u>HS3</u>	<u>HS4</u>
Total kilometres traversed (km)	5.39	7.0	3.11	5.09
Datum level for corrections (m)	274	305	335	335
Weathering velocity (m/s)	1006	1006	914	914
Sub-weathering velocity (m/s)	2530	2530	3048	3048
Static correction method	Uphole times checked by first-break analyses			
Velocity function (m/s)	$V_a = 3658$			
Derivation of velocity function	$t:\Delta t$ analysis			
Total depth drilled (m)	7590	2149	677	2161
Total number of holes drilled	297	106	37	110
Total number of drill field hours	743.5	113.5	47	76.5
Total number of drilling hours	417	74	18	39
Average penetration rate (m/hr)				
Mayhew	18.2	30.8	37.5	55.5
Failing	18.1	22.2	-	-
Total number of recording field hours	285.5	69.5	20	59

Total number of recording time (hr)

Experimental	123.25	22.5	2.0	13.5
Production	62.75	35	7.5	25

Total number of profiles

Experimental	94	19	2	14
Production	22	24	10	16

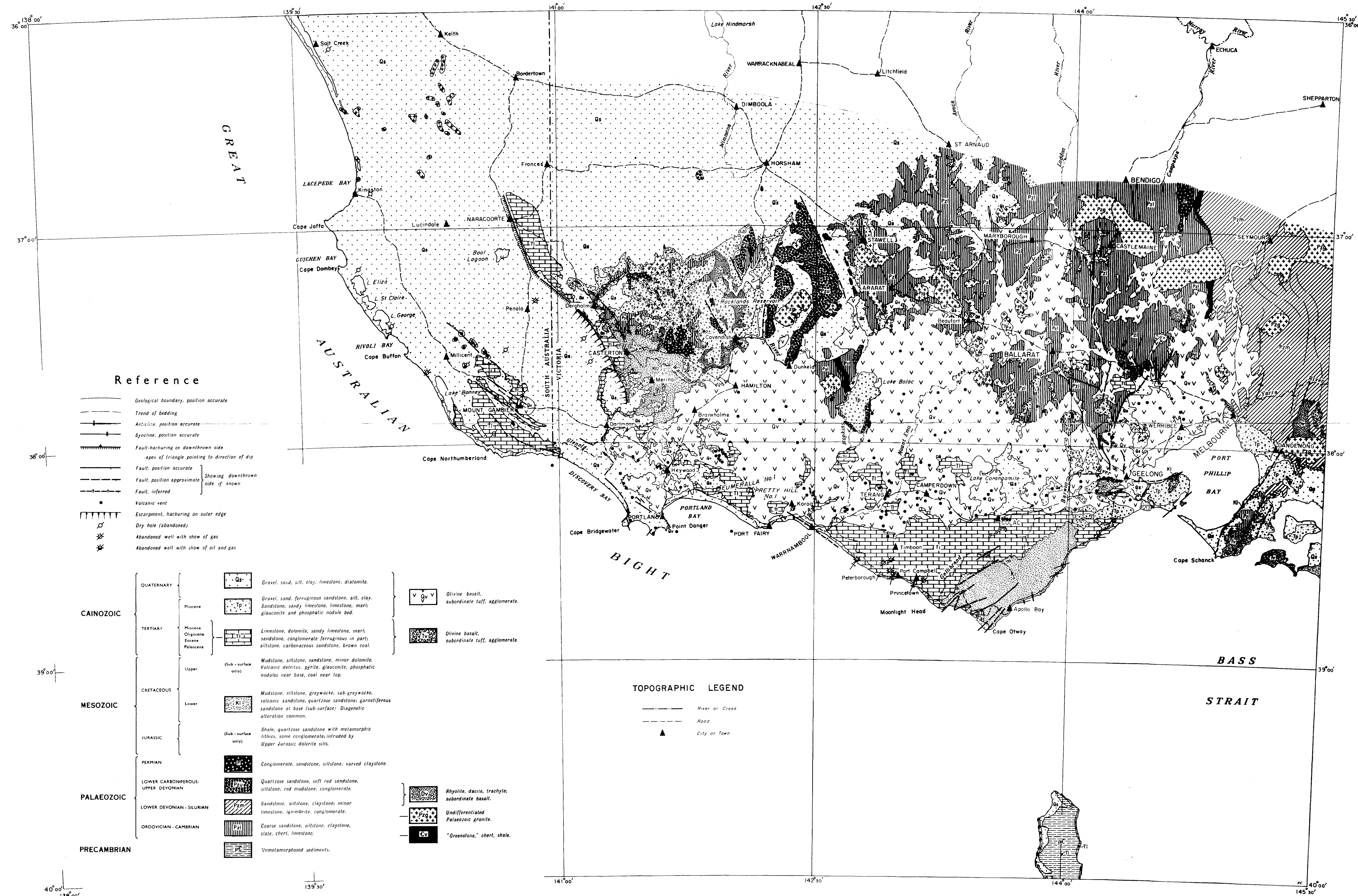
Total explosives used (kg)

4.54 kg	6940	1470	499	2450
2.27 kg	848	18	-	36

Total detonators used

31 m	492	103	38	128
9 m	8	-	-	-

GEOLOGICAL MAP OTWAY BASIN AND ADJACENT AREAS VICTORIA AND SOUTH AUSTRALIA



Reference

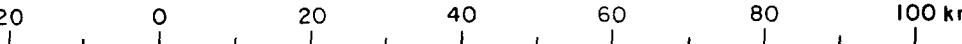
- Geological boundary, position accurate
- Trend of bedding
- Anticline, position accurate
- Syncline, position accurate
- Fault-hachuring on downthrown side
apex of triangle pointing to direction of dip
- Fault, position accurate
- Fault, position approximate
- Fault, inferred
- Volcanic vent
- Escarpment, hachuring on outer edge
- Dry hole (abandoned)
- Abandoned well with show of gas
- Abandoned well with show of oil and gas

CAINOZOIC	QUATERNARY	Qs	Gravel, sand, silt, clay, limestone, diatomite.	V	Olivine basalt, subordinate tuff, agglomerate.
	Pliocene	P	Gravel, sand, ferruginous sandstone, silt, clay, sandstone, sandy limestone, limestone, marl; glauconite and phosphatic nodule bed.	Vv	Olivine basalt, subordinate tuff, agglomerate.
	TERTIARY Miocene Oligocene Eocene Paleocene	L O E P	Limestone, dolomite, sandy limestone, marl; sandstone, conglomerate ferruginous in part; siltstone, carbonaceous sandstone, brown coal. Mudstone, siltstone, sandstone, minor dolomite. Volcanic detritus, pyrite, glauconite, phosphatic nodules near base, coal near top.		
MESOZOIC	CRETACEOUS	Upper Lower	(Sub-surface only) Mudstone, siltstone, greywacke, sub-greywacke, volcanic sandstone, quartzose sandstone; garnetiferous sandstone at base (sub-surface) Diagenetic alteration common.		
	JURASSIC	(Sub-surface only)	Shale, quartzose sandstone with metamorphic lithics, some conglomerate, intruded by Upper Jurassic dolerite sills.		
PALAEOZOIC	PERMIAN		Conglomerate, sandstone, siltstone, varved claystone.		
	LOWER CARBONIFEROUS-UPPER DEVONIAN		Quartzose sandstone, soft red sandstone, siltstone, red mudstone, conglomerate.	Dv	Rhyolite, dacite, trachyte, subordinate basalt.
	LOWER DEVONIAN-SILURIAN	Pm	Sandstone, siltstone, claystone, minor limestone, ignimbrite, conglomerate.		Undifferentiated Palaeozoic granite.
	ORDOVICIAN-CAMBRIAN	Po	Coarse sandstone, siltstone, claystone, slate, chert, limestone.		"Greenstone," chert, shale.
PRECAMBRIAN		Pc	Unmetamorphosed sediments.		

TOPOGRAPHIC LEGEND

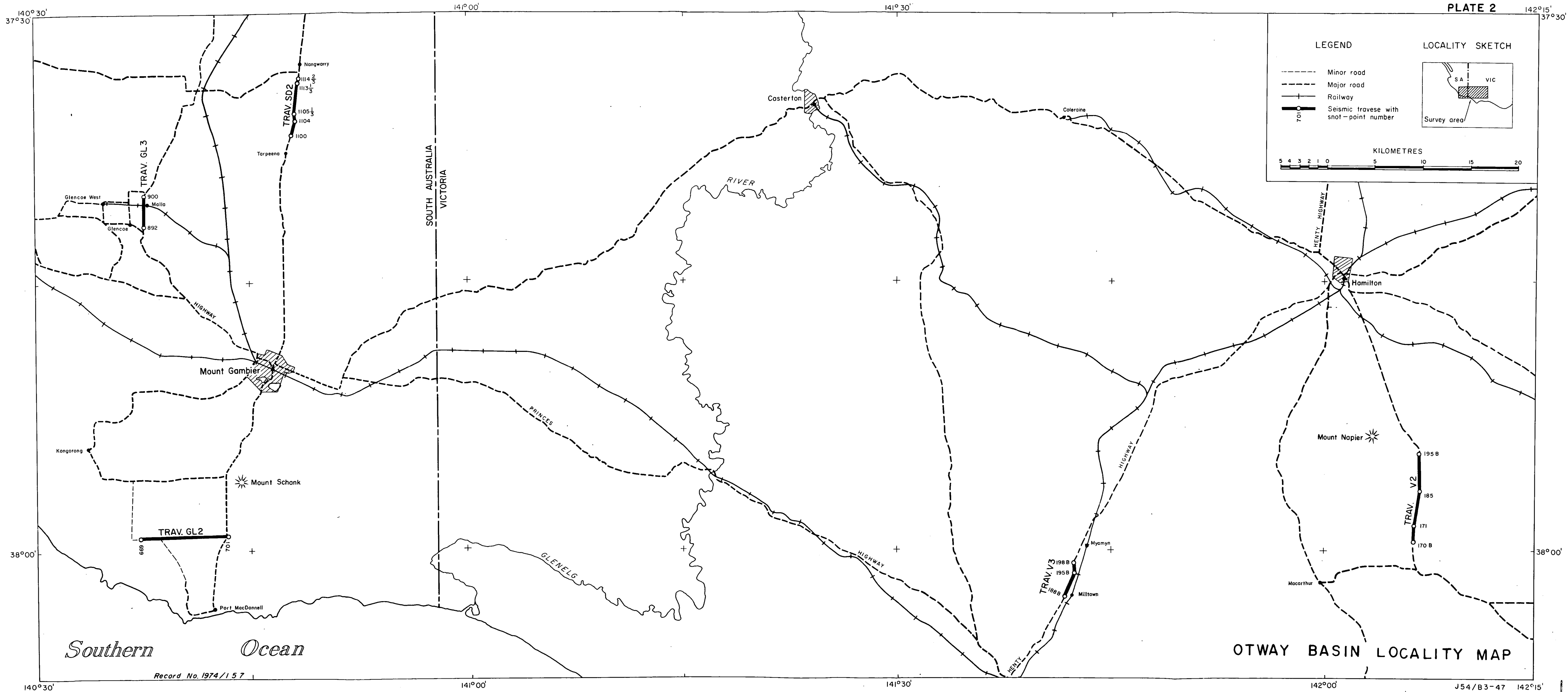
- River or Creek
- Road
- City or Town

Scale 1:1 000 000



Geology based mainly on the map of Sprigg (1952) for South Australia and the Geological Map of Victoria issued by the Geological Survey of Victoria in 1964
Bureau of Mineral Resources, Geology and Geophysics. August 1966 (Based on X-AUS-1-29)

Record No.1974/157



NO. 1 PRETTY HILL

SYNTHETIC SEISMOGRAM

PRESENTATION BY

SOCONY MOBIL OIL COMPANY
FIELD RESEARCH LABORATORY
DALLAS, TEXAS

TYPE. FIRST ORDER SURFACE MULTIPLE

COMPANY. PRATT BRIDGE HILL CO. PTY. LTD.

WELL. PRETTY HILLS No. 1 IN 503'

FIELD. COUNTY.

STATE. VICTORIA COUNTRY. AUSTRALIA

TWO WAY TRAVEL TIME BELOW 205.77 ELEVATION DATUM

UPPER TRACES FILTERED. 15°-45°

LOWER TRACE ACOUSTIC VELOCITY LOG

FORMATION TOPS AND DEPTHS INDICATED IN FEET BELOW 43

ORIGINAL C.V.E. BY

SURFACE REFLECTION COEFFICIENT

☐ 1.00
☐ .63
☐ .39

TIME SHIFT IN MILLISECONDS

☐ +8
☐ 0
☐ -8
☐ -16

JOB NO. 250.3-354 SURVEY NO. 8037 DATE FEBRUARY 1963

FILTERED PRIMARY REFLECTIONS
PLUS
FILTERED FORM

FILTERED FORM

FILTERED FORM

FILTERED PRIMARY REFLECTIONS
(NORMAL SYNTHEIC)

UNFILTERED PRIMARY REFLECTIONS
(C.V.L.)

UNFILTERED FORM

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

TOP OF LOG
134

BASE OF
PORTLAND
LINE 410

TOP UPPER
SANDSHIP
1110

TOP LOWER
SANDSHIP
1290

MEETING
BAND

PRETTY HILL
SANDSTONE

DTABASE
7880

END OF
LOG 9124

Record No. 1974 /157

SYNTHETIC SEISMOGRAM
PRETTY HILL NO.1 WELL

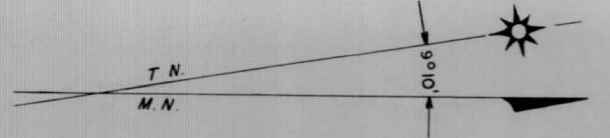
G 438-4

Note: Depth in feet.

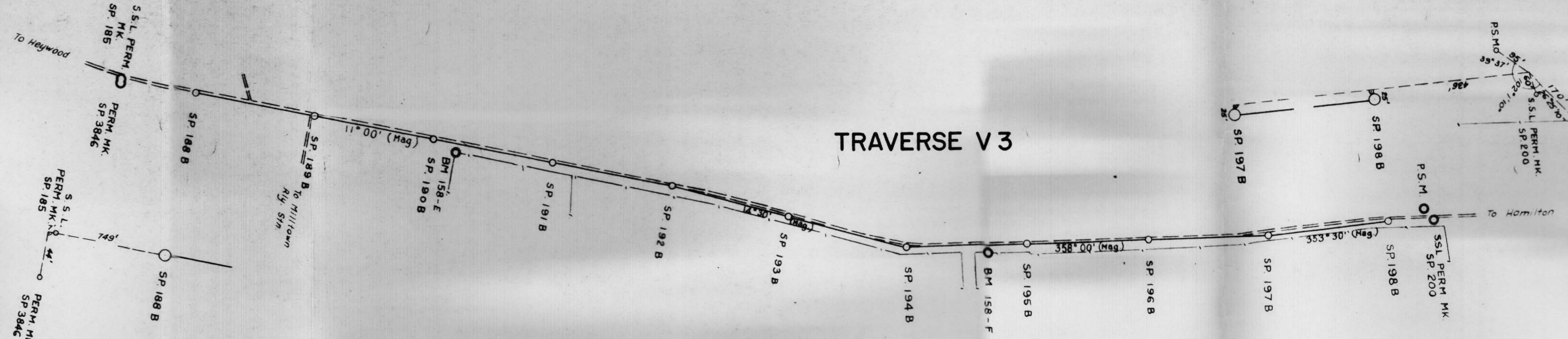
OTWAY BASIN

SHOT-POINT LOCATION MAP

TRAVERSES V2 and V3

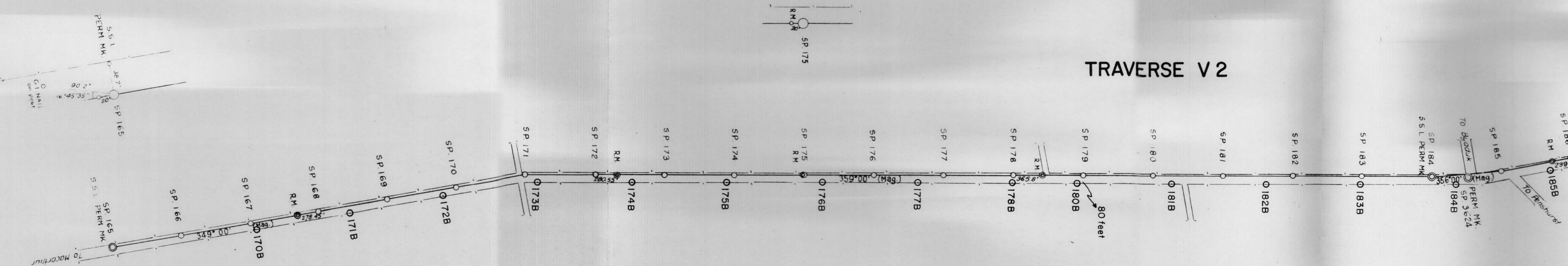


TRAVERSE V3



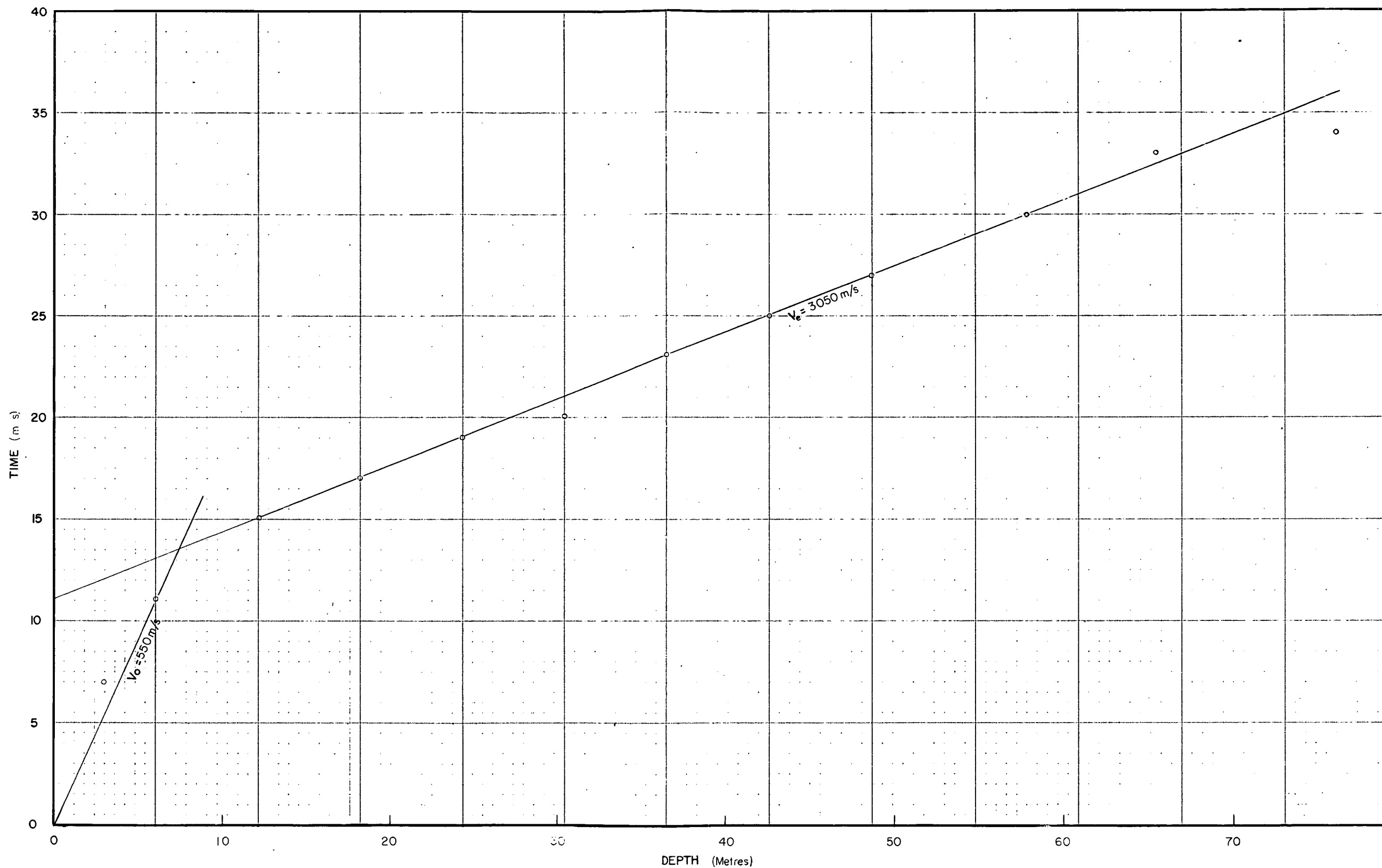
SHOTPOINT	RED LEVEL
188 B	435.0
189 B	427.8
190 B	436.7
191 B	436.6
192 B	440.1
193 B	426.6
194 B	399.9
195 B	394.3
196 B	415.1
197 B	417.7
198 B	405.5
PSM	404.1
	400.3

TRAVERSE V2



SHOTPOINT	RED LEVEL
165	605.5
166	599.8
167	601.1
168	608.8
169	607.1
170	603.4
171	610.0
172	617.4
173	610.3
174	598.8
175	615.2
176	617.2
177	634.1
178	634.5
179	621.2
180	626.5
181	615.7
182	615.7
183	615.7
184	645.0
185	643.2
186	648.0
187	623.9
188	623.9
189	655.8
190	648.7
191	641.9
192	660.8
193	662.9
194	664.9
195	643.2
196	643.3
197	671.0
198	683.6
200	689.3

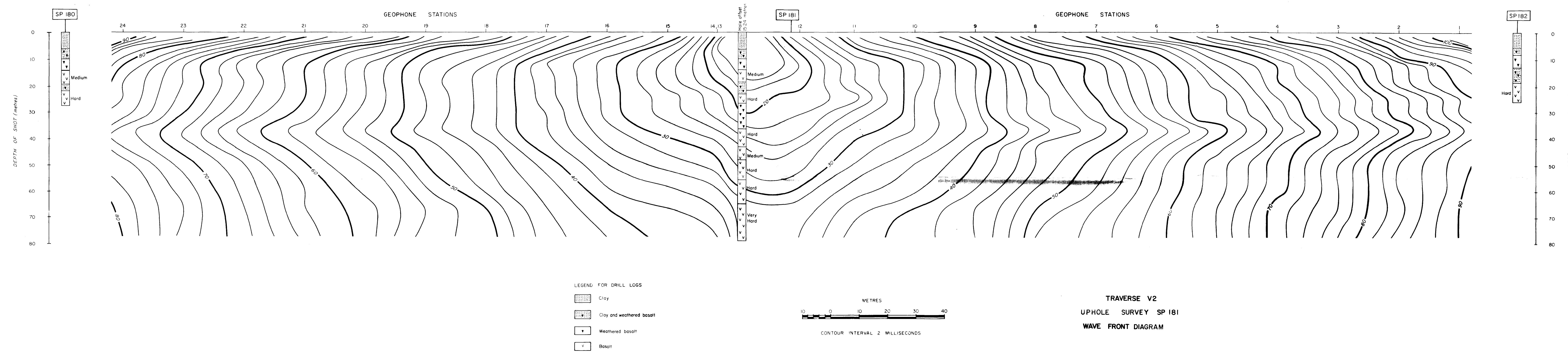
Note: Location map based on Department of the Interior survey map. Measurements were made in feet during survey.



CLAY	CLAY + WEATHERED BASALT	WEATHERED BASALT	MEDIUM BASALT	CLAY + WEATHERED BASALT	HARD BASALT	WEATHERED BASALT	HARD BASALT	MEDIUM BASALT	HARD BASALT	VERY HARD BASALT
------	-------------------------	------------------	---------------	-------------------------	-------------	------------------	-------------	---------------	-------------	------------------

DRILL LOG

TRAVERSE V2
UPHOLE SURVEY SP 181



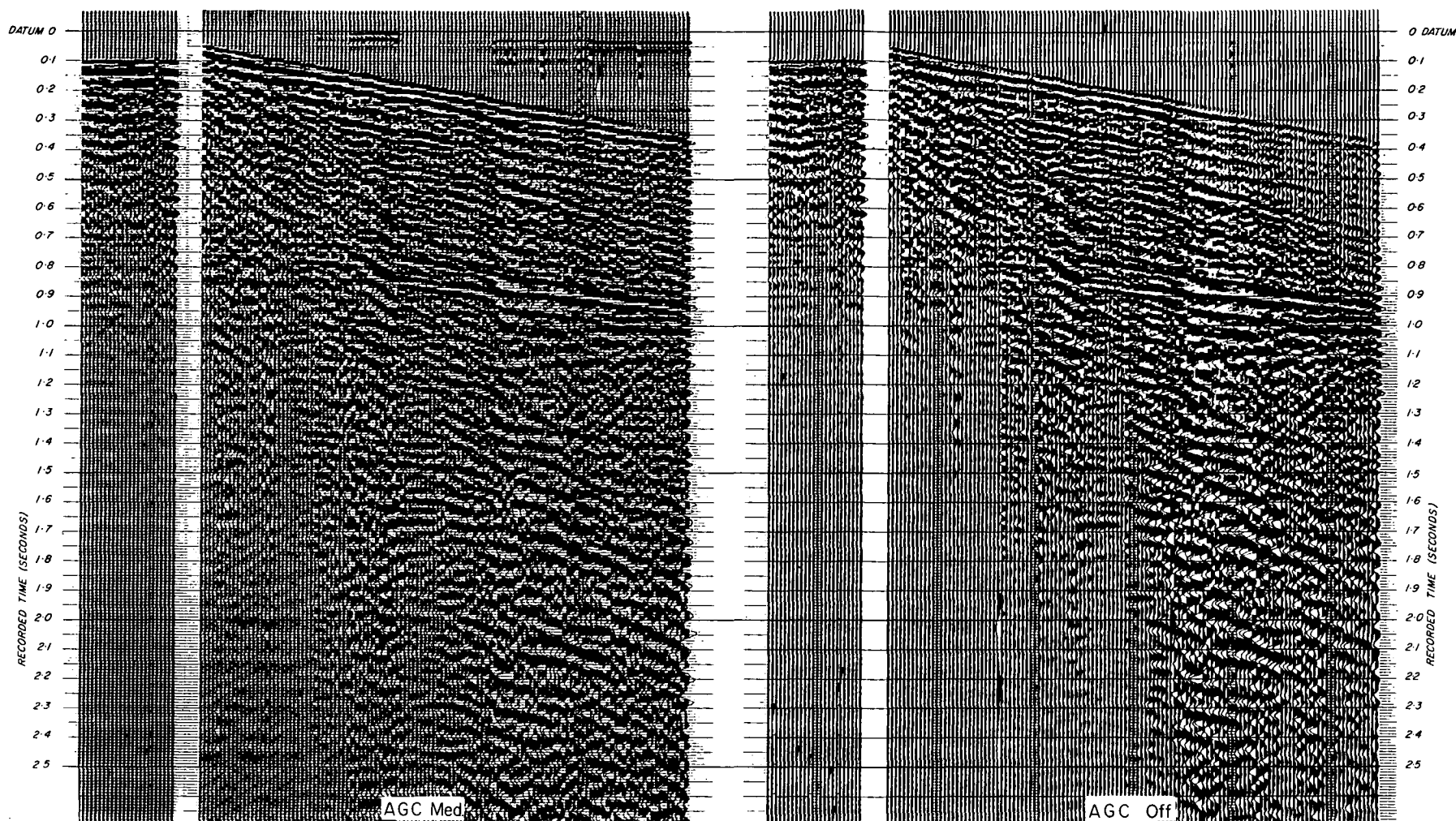
DISTANCE
(m) Cross Spread at 268m 91.4m

1179.6m Cross Spread at 268m 91.4m

1179.6m DISTANCE (m)

PLATE 7

RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder: PMR 20

Amplifiers: 7000B

Filters: KO-K120
PREFILTERS 18Hz, 12dB/O

A.G.C.: OFF

Gain Initial: }
Final: } VARIOUS

Geophones: HSJ-14Hz

Geophone pattern:
8/ trace, bunched

Shot-hole pattern:
—

PLAYBACK INFORMATION

Filters: 1/16 - 1/135

A.G.C.: Med. and Off

Gain Initial: With A.G.C. W/out A.G.C.
-40 -40

Final: -20 -30

Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Longitudinal Spreads - 9.1 between traces

Transverse Spreads - 7.6 between traces

TRAVERSE V2

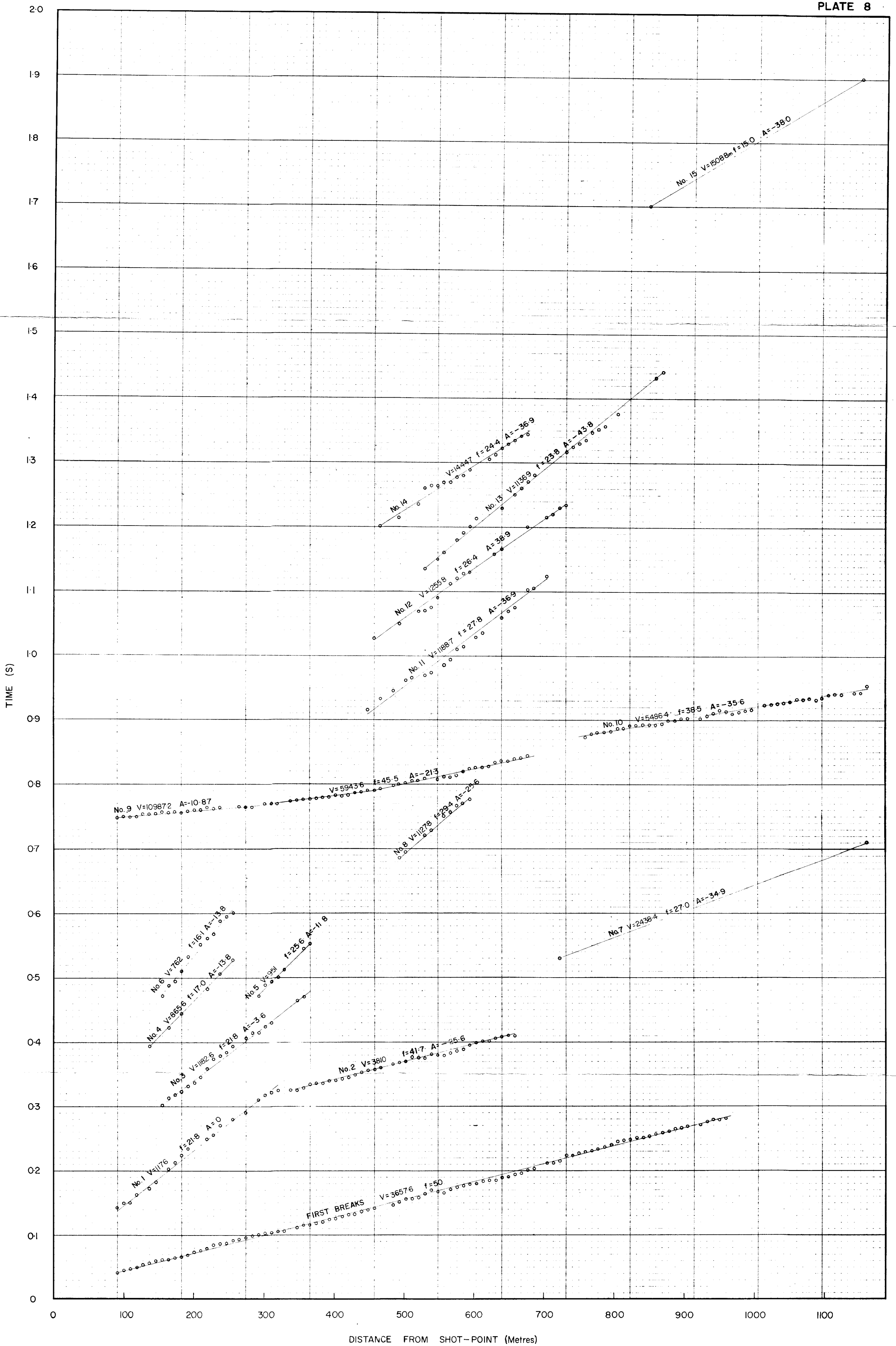
NOISE ANALYSIS SP180

RECORDED BY: Seismic Party No 2

SECTION BY: Bureau of Mineral Resources
Playback Centre Sil MS 42

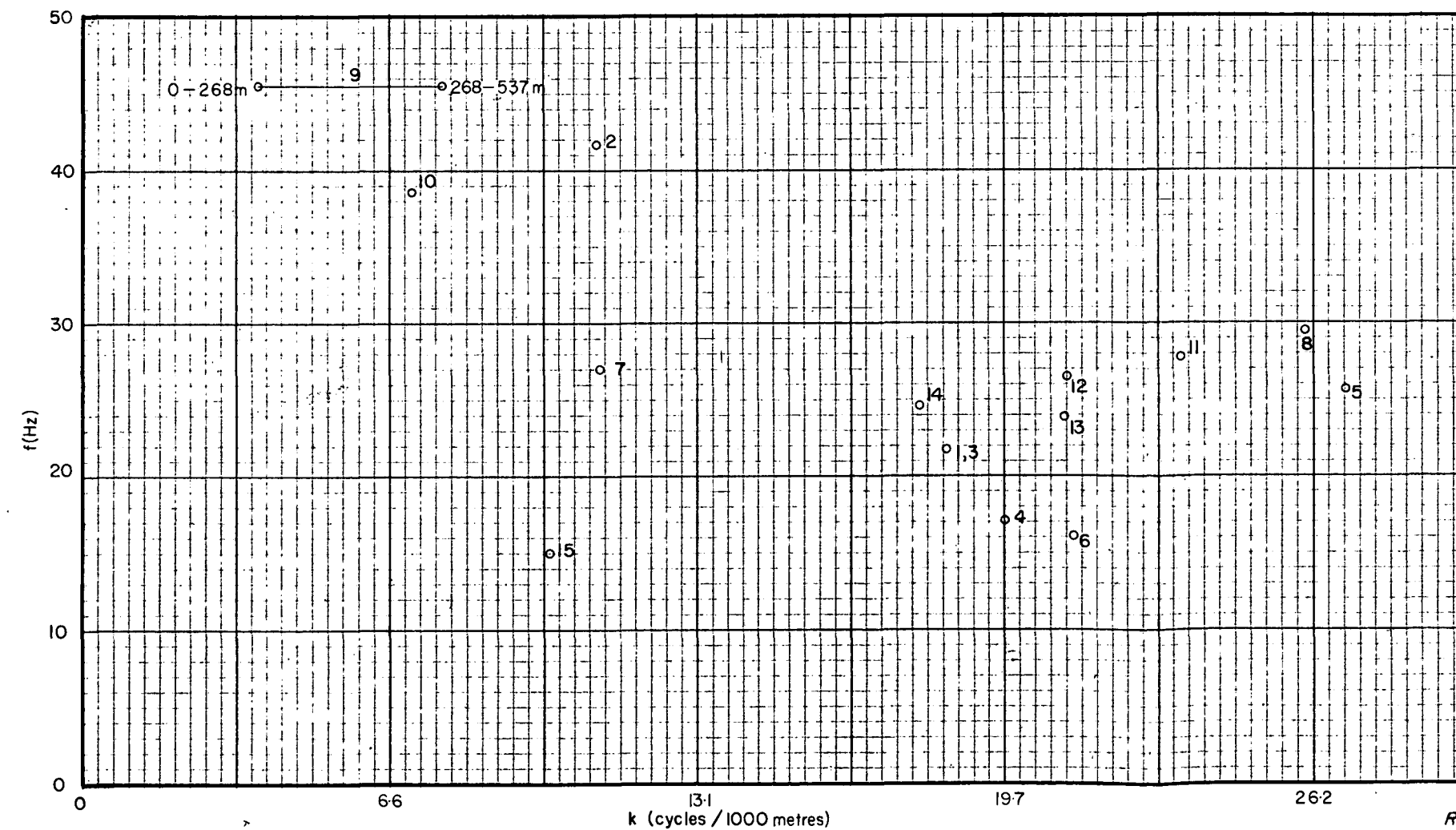
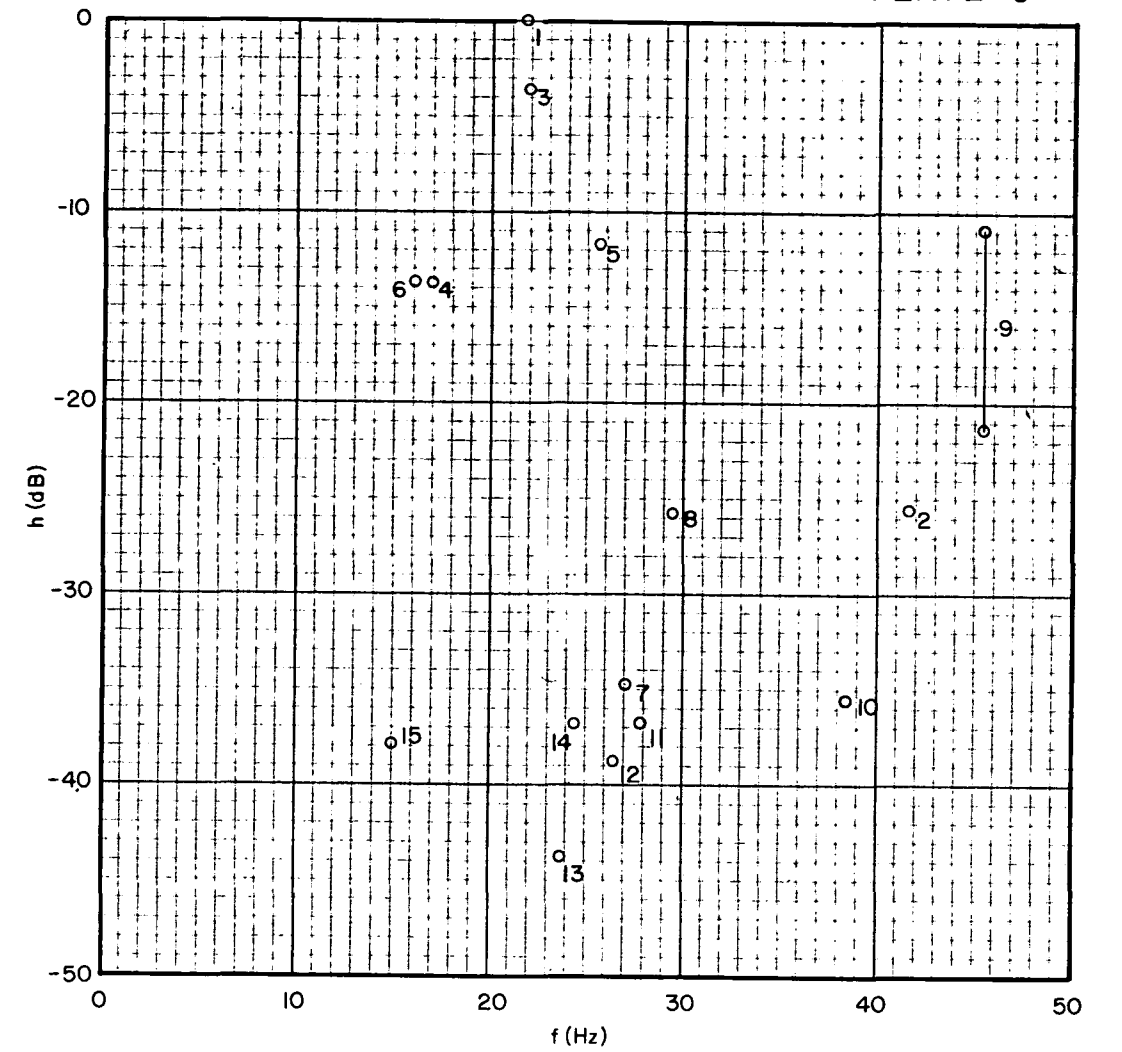
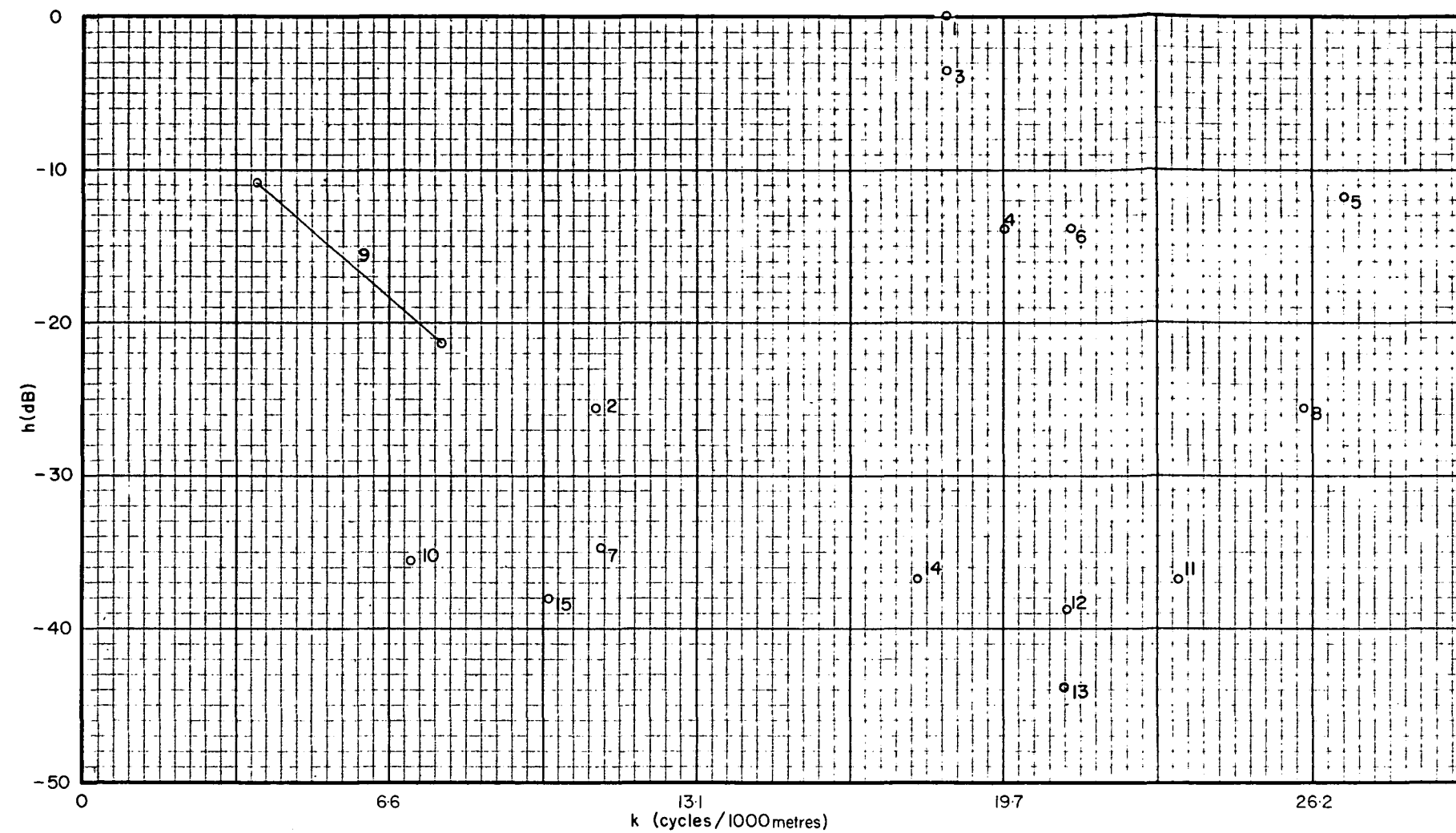
J54/B3-4

Record No 1974/157



V=Velocity (m/s)
 f=Estimated Peak Frequency (Hz)
 A=Amplitude in dB relative to Amplitude of First Break

TRAVERSE V2
 NOISE ANALYSIS SP 180



h = Relative Amplitude
k = Wave number
f = Frequency

TRAVERSE V2
NOISE ANALYSIS SP 180

CORRECTED
RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000B

Filters : Prefilters 18 Hz 12 dB/o
K0-K92

A.G.C. : Med

Gain Initial : -60

Final : -20

Geophones : HSJ-14 Hz

Geophone pattern :

As indicated

Shot-hole pattern :

As indicated

PLAYBACK INFORMATION

Filters : 1/20-1/78

A.G.C. : Med

Gain Initial : -40

Final : -20

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

t: Δt

HORIZONTAL SCALE

As indicated

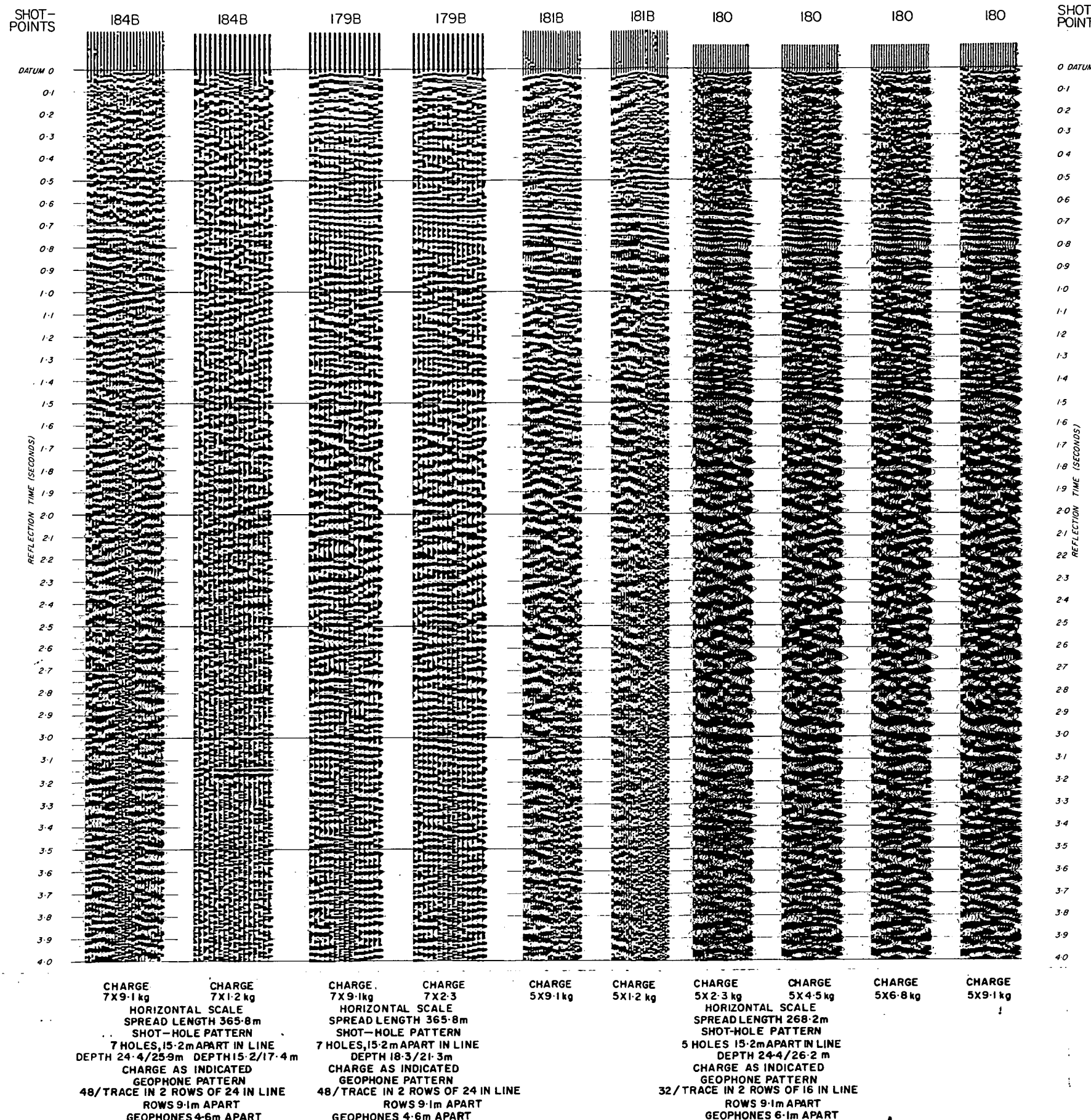
Record No. 1974/157

TRAVERSE V2
CHARGE COMPARISONS

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources
Playback Centre SIE MS 42

J54/B3-44



SHOT-POINTS

179

179

180B

180B

181B

180B

181B

SHOT-POINTS

CORRECTED
RECORD SECTION PLATE II

DATUM 0

0.1

0.2

0.3

0.4

0.5

0.6

0.7

0.8

0.9

1.0

1.1

1.2

1.3

1.4

1.5

1.6

1.7

1.8

1.9

2.0

2.1

2.2

2.3

2.4

2.5

2.6

2.7

2.8

2.9

3.0

3.1

3.2

3.3

3.4

3.5

3.6

3.7

3.8

3.9

4.0

4.1

REFLECTION TIME (SECONDS)

SHOT-HOLE PATTERN
5 HOLES 15.2m APART IN LINE
DEPTH 24.4/26.8m
CHARGE 5X9.1kg
HORIZONTAL SCALE
SPREAD LENGTH 268.2m
GEOPHONE PATTERN
32/TRACE IN 2 ROWS OF 16
IN LINE
ROWS 9.1m GEOPHONES 6.1m APART

SHOT-HOLE PATTERN
3 HOLES 15.2m APART IN LINE
DEPTH 24.4/25.9m
CHARGE 3X13.6kg
HORIZONTAL SCALE
SPREAD LENGTH 268.2m
GEOPHONE PATTERN
48/TRACE IN 2 ROWS OF 24 IN LINE
GEOPHONES 6.1m APART ROWS 9.1m APART

SHOT-HOLE PATTERN
4 HOLES 30.5m APART IN LINE
DEPTH 24.4/25.9m
CHARGE 4X11.3kg

SHOT-HOLE PATTERN
5 HOLES 15.2m APART IN LINE
DEPTH 24.4/25.9m
CHARGE 5X9.1kg
HORIZONTAL SCALE
SPREAD LENGTH 365.8m
EX AS INDICATED
GEOPHONE PATTERN
48/TRACE IN 2 ROWS OF 24 IN LINE
ROWS 9.1m APART
GEOPHONES 6.1m APART

SHOT-HOLE PATTERN
7 HOLES 15.2m APART 4.6m
APART IN LINE
DEPTH 24.4/27.4m
CHARGE 7X9.1kg
HORIZONTAL SCALE
SPREAD LENGTH 365.8m
GEOPHONE PATTERN
48/TRACE IN 2 ROWS OF 24
IN LINE
ROWS 9.1m APART
GEOPHONES 6.1m APART

0 DATUM

0.1

0.2

0.3

0.4

0.5

0.6

0.7

0.8

0.9

1.0

1.1

1.2

1.3

1.4

1.5

1.6

1.7

1.8

1.9

2.0

2.1

2.2

2.3

2.4

2.5

2.6

2.7

2.8

2.9

3.0

3.1

3.2

3.3

3.4

3.5

3.6

3.7

3.8

3.9

4.0

4.1

REFLECTION TIME (SECONDS)

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000B

Filters : Prefilters 18 Hz, 12dB/o
KO-K92

A.G.C. : Med

Gain Initial : -60

Final : -20

Geophones : HSJ-14 Hz

Geophone pattern :

48/trace in 2 rows of 24 in line

Rows 9.1m apart

Geophones 6.1m apart

Shot-hole pattern :

As indicated

PLAYBACK INFORMATION

Filters : 1/20 - 1/78

A.G.C. : Med

Gain Initial : -40

Final : -20

Trip delay : Nil

Compositing : Nil

VELOCITY INFORMATION

1:Δt

HORIZONTAL SCALE

As indicated

Record No 1974/157

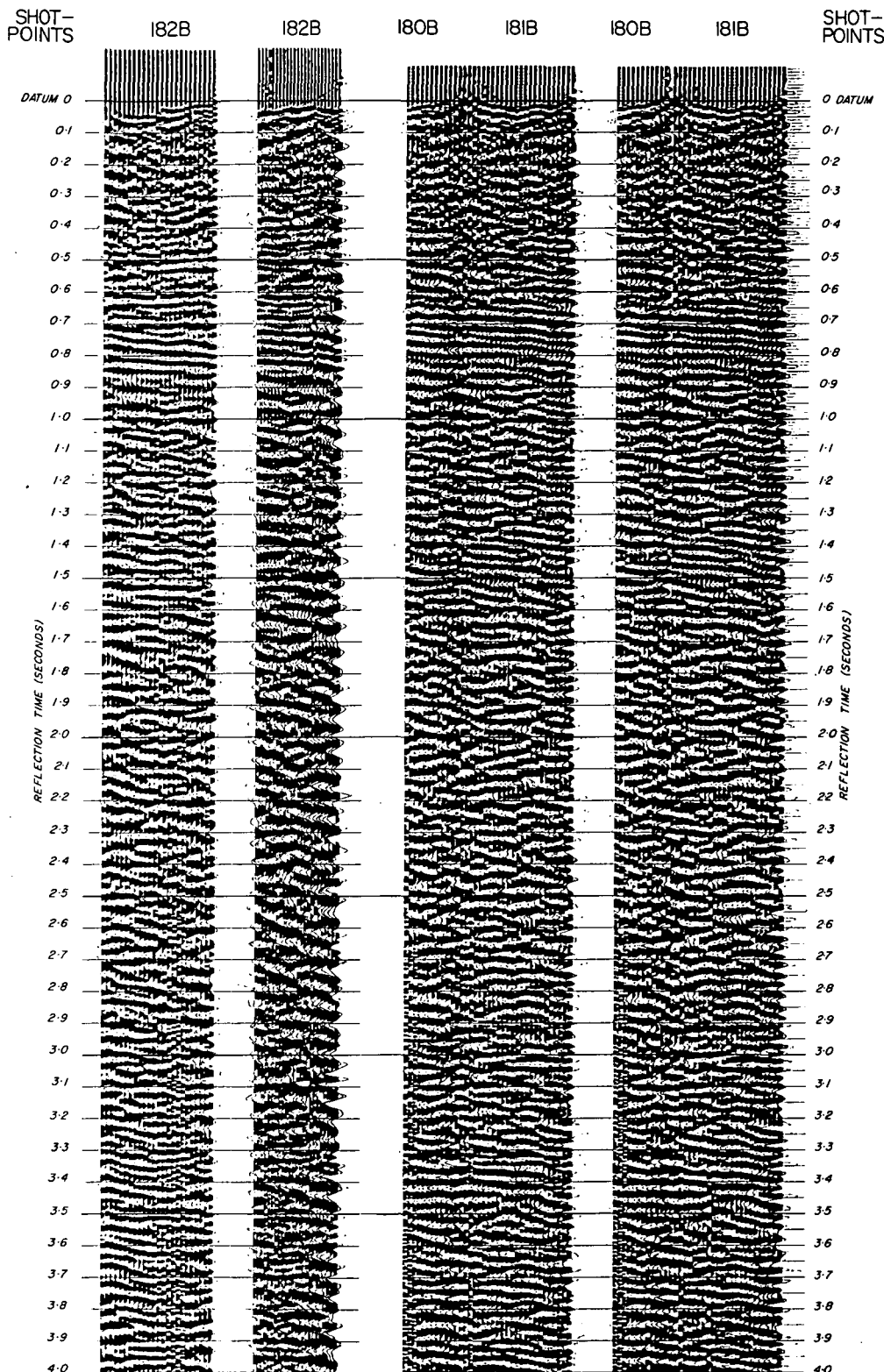
TRAVERSE V2
SHOT-HOLE PATTERN COMPARISONS

Prepared BY: Seismic Party No. 2

Checked BY: Bureau of Mineral Resources
Playback Centre SIE MS 42

J54/B3-42

CORRECTED
RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder : PMR 20

Amplifiers : 7000 B

Filters : KO-K92

PREFILTERS 18 Hz, 12 dB/o

A.G.C. : Med.

Gain Initial : -60

Final : -20

Geophones : HSJ-14 Hz

Geophone pattern :

As Indicated

Shot-hole pattern :

As Indicated

PLAYBACK INFORMATION

Filters : 1/20 - 1/78

A.G.C. : Med.

Gain Initial : -40

Final : -20

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

t.Δt

HORIZONTAL SCALE

As Indicated

Record No. 1974/157

TRAVERSE V2

GEOPHONE PATTERN COMPARISONS

GEOPHONE PATTERN
48/TRACE IN 2 ROWS OF 24 IN LINE
ROWS 9.1m APART
GEOPHONES 4.6m APART
HORIZONTAL SCALE
SPREAD 274.3m-0-457.2m
SHOT-HOLE PATTERN
7 HOLES 15.2m APART IN LINE
DEPTH 23.5/25.9m
CHARGE 7 X 9-1kg

GEOPHONE PATTERN
16/TRACE, 6.1m APART IN LINE
HORIZONTAL SCALE
SPREAD LENGTH 365.8
SHOT-HOLE PATTERN
5 HOLES 15.2m APART IN LINE
DEPTH 9.8/12.2m
CHARGE 5 X 9-1kg

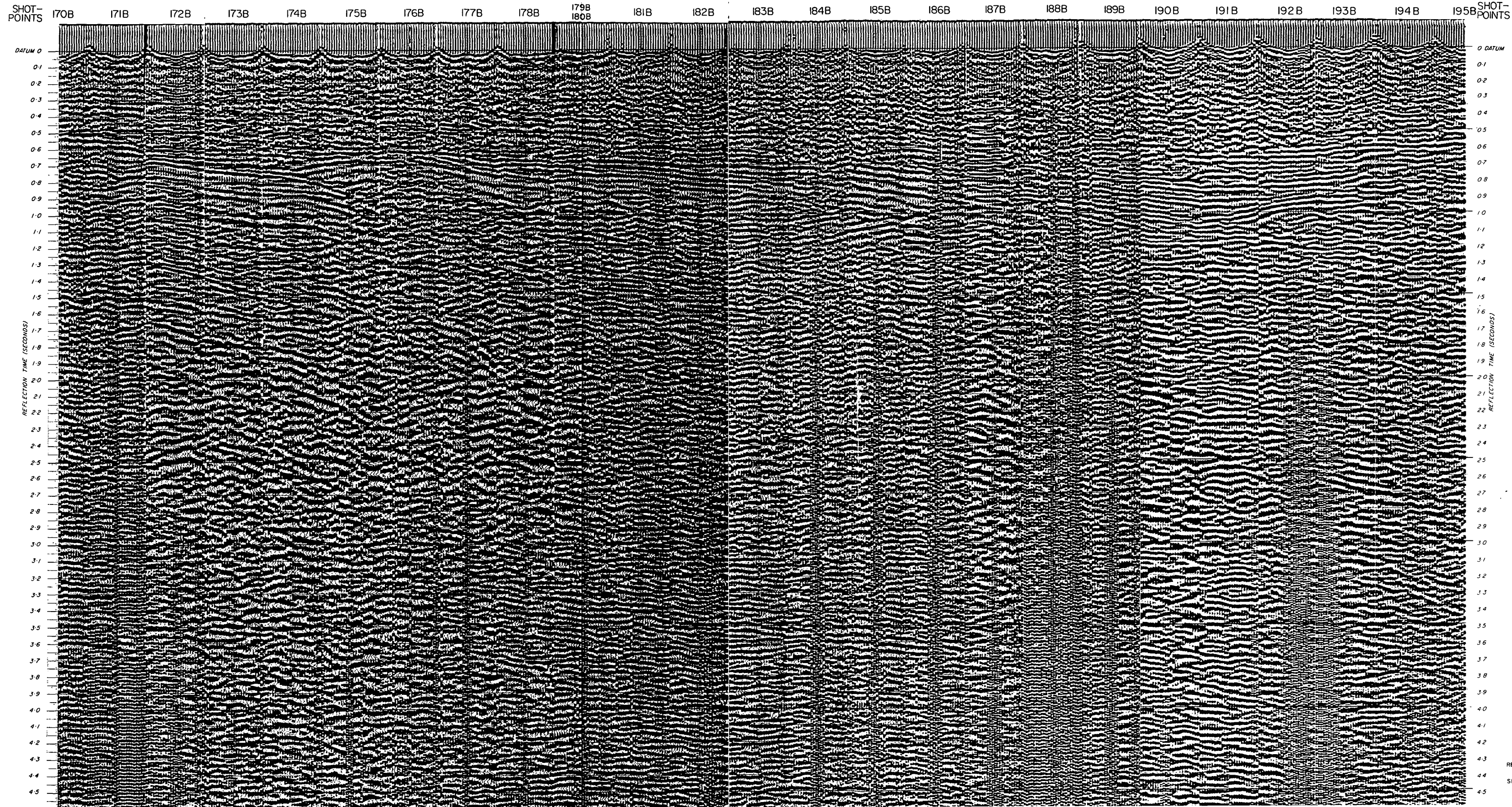
GEOPHONE PATTERN
24/TRACE, 4.6m APART IN LINE
HORIZONTAL SCALE
SPREAD LENGTH 365.8
SHOT-HOLE PATTERN
7 HOLES 15.2m APART IN LINE
DEPTH 24.4/27.4m
CHARGE 7 X 9-1kg

GEOPHONE PATTERN
48/TRACE IN 2 ROWS OF 24
IN LINE, ROWS 9.1m APART
GEOPHONES 4.6m APART
HORIZONTAL SCALE
SPREAD LENGTH 365.8
SHOT-HOLE PATTERN
7 HOLES 15.2m APART IN LINE
DEPTH 24.4/27.4m
CHARGE 7 X 9-1kg

RECORDED BY : Seismic Party No 2

J54/B3-45A

SECTION BY : Bureau of Mineral Resources
Playback Centre SIE MS 42



CORRECTED
RECORD SECTION

PLATE 13

RECORDING INFORMATION

Magnetic Recorder: PMR 20

Amplifiers: 7000B

Filters: KO-K92
PREFILTERS 18Hz, 12dB/o

A.G.C.: Med.

Gain Initial: -60

Final: -20

Geophones: HSJ-14Hz

Geophone pattern:

SP170B, 171B, 172B, and 180B-195B SP173B-179B

48/traces in 2 rows of 24 in line 32/traces in 2 rows of 16 in line

Rows 9.1m apart Rows 9.1m apart

Geophones 4.6m apart Geophones 6.1m apart

Station interval 30.5m

Shot-hole pattern:

SP170B, 171B, 172B, and 180B-195B SP173B-179B

7 holes, 15.3m apart in line 5 holes, 15.3m apart in line

Depth 24.3/27.4m Depth 24.3/27.4m

Charge 7x9.1kg Charge 5x9.1kg

PLAYBACK INFORMATION

Filters: 1/20-1/78

A.G.C.: Med.

Gain Initial: -40

Final: -20

Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

1:Δt

HORIZONTAL SCALE

0 300 600 900 METRES
0 366 732

Record No. 1974/157

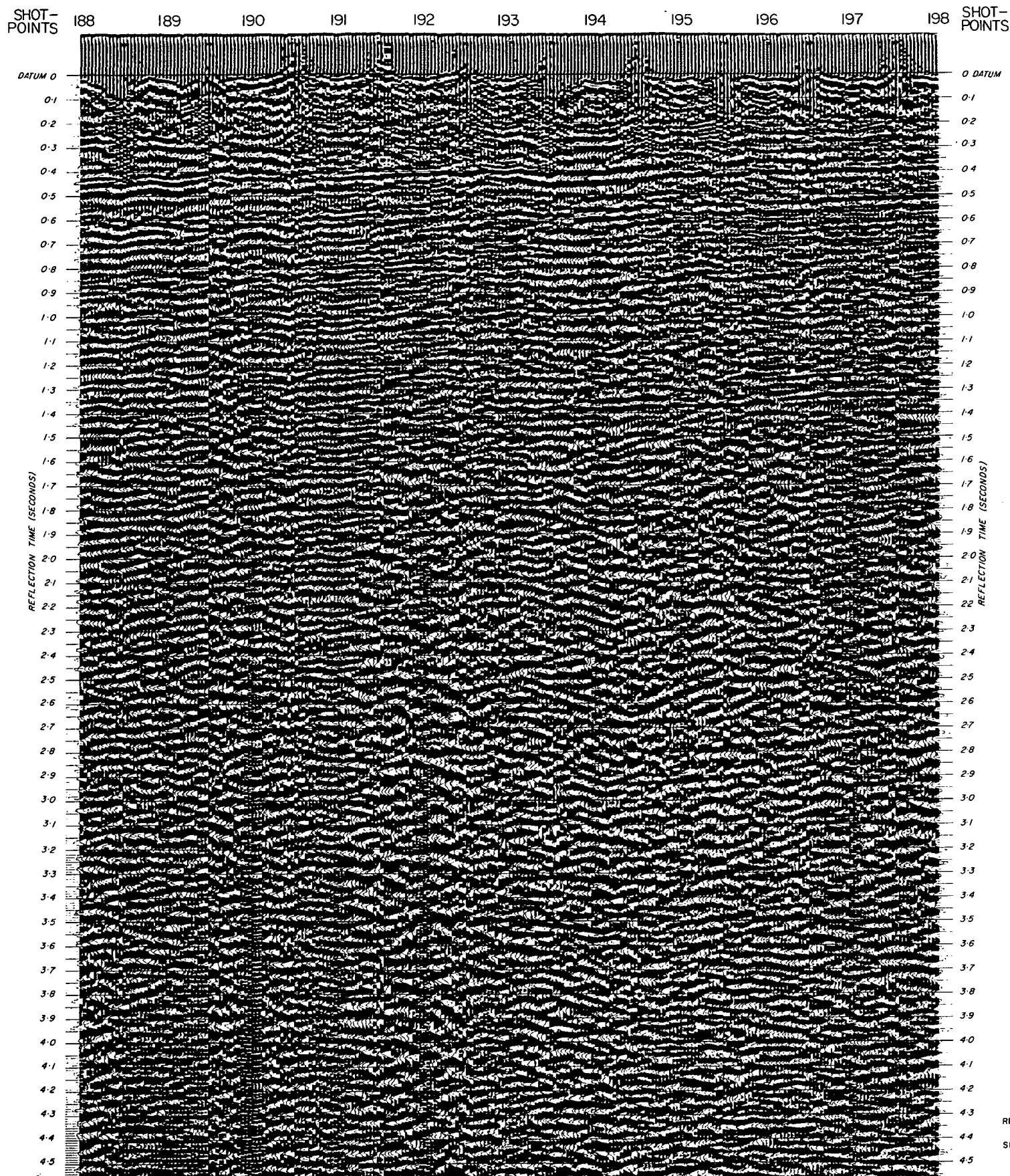
TRAVERSE V2

SP170B - SP195B

RECORDED BY: Seismic Party No 2

SECTION BY: Bureau of Mineral Resources
Playback Centre Silt 45 42

J54/B3-38



CORRECTED RECORD SECTION

PLATE 14

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B
Prefilters 18Hz 12dB/octave
Filters: KO-K92

A.G.C.: Med

Gain Initial: -60

Final: -20

Geophones: HSJ-14Hz

Geophone pattern:
48/trace in 2 rows of 24 in line
Rows 91m apart
Geophones 4.6m apart
Station Interval 30.5m

Shot-hole pattern:
7 holes, 15.2m apart in line
Depth 25.9/27.4m
Charge 7 x 91kg

PLAYBACK INFORMATION

Filters: 1/20 - 1/78

A.G.C.: Med

Gain Initial: -50

Final: -20

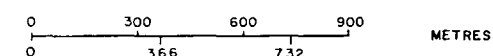
Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

1 Δt

HORIZONTAL SCALE



TRAVERSE V3

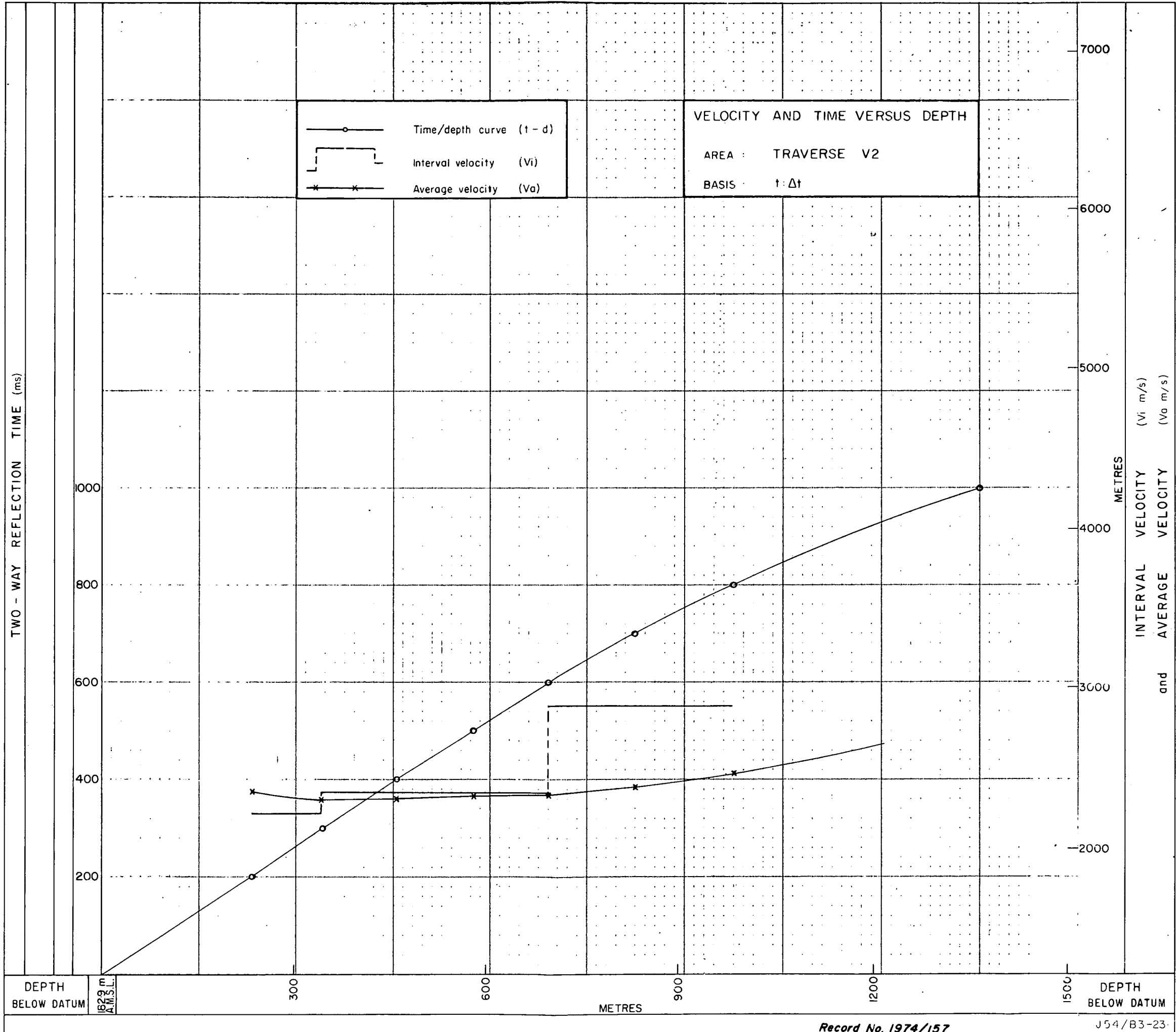
SP188 - SP198

RECORDED BY: Seismic Party No. 2

SECTION BY: Bureau of Mineral Resources
Playback Centre SIE MS 42

Record No 1974/157

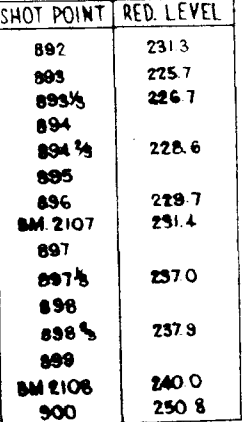
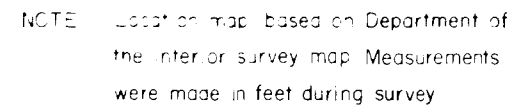
J54/B3-37

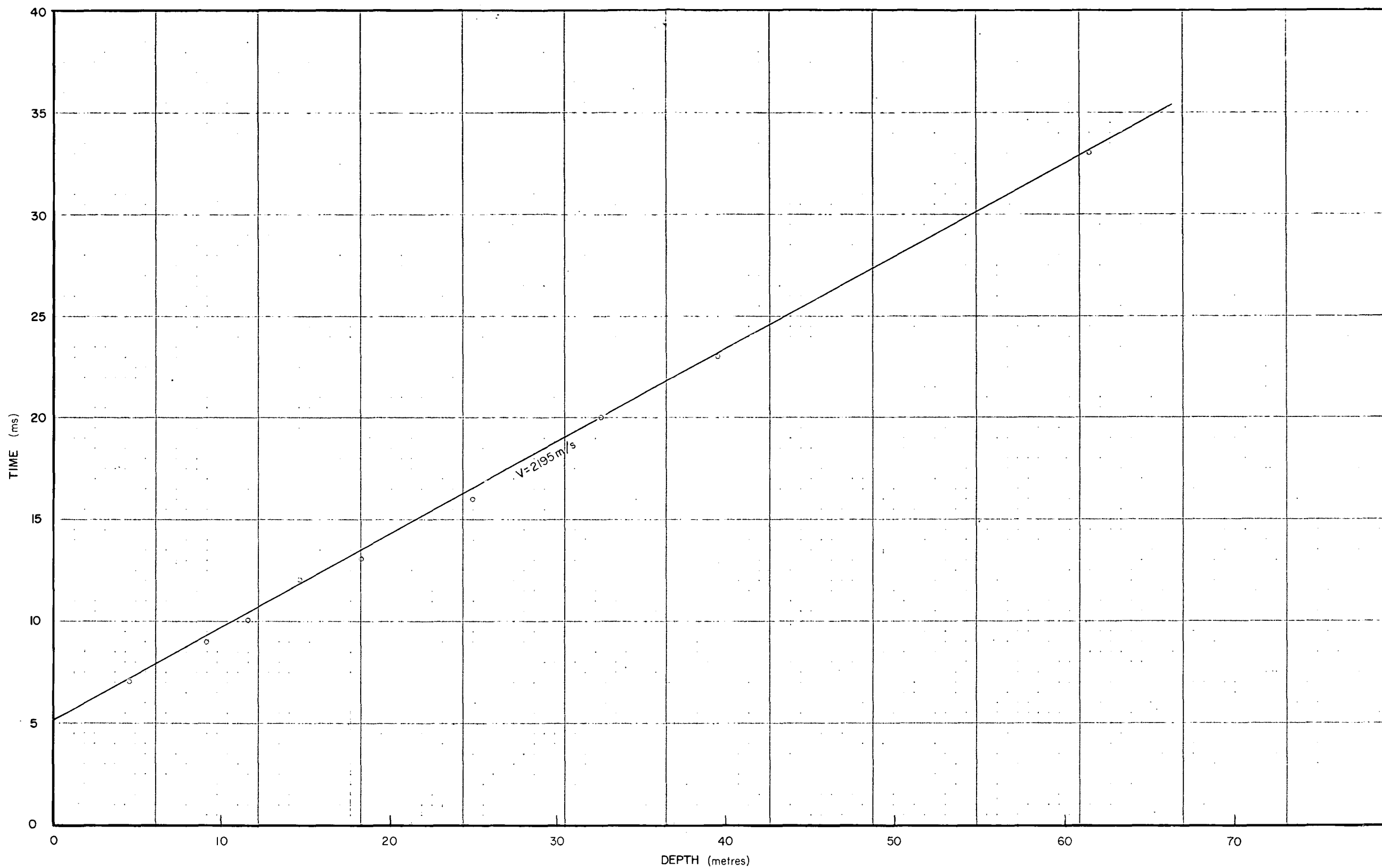




SHOT-POINT LOCATION MAP

TRAVERSES GL2 and GL3





TRAVERSE G L 2
UPHOLE SURVEY SP 689

PLATE 18
RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20
Amplifiers : 7000B
Filters : PREFILTERS 18Hz, 12dB/o
A.G.C. : Off
Gain Initial : Various
Final : Various
Geophones : HSJ-14Hz
Geophone pattern :
8/trace, bunched

Shot-hole pattern :

Depth 18.3/19.5m
Charge as indicated

PLAYBACK INFORMATION

Filters : 0-1/135
A.G.C. : Med. Off
Gain Initial : -40 -40
Final : -20 -40
Trip delay : 0-2sec
Compositing : Nil

VELOCITY INFORMATION

-

HORIZONTAL SCALE

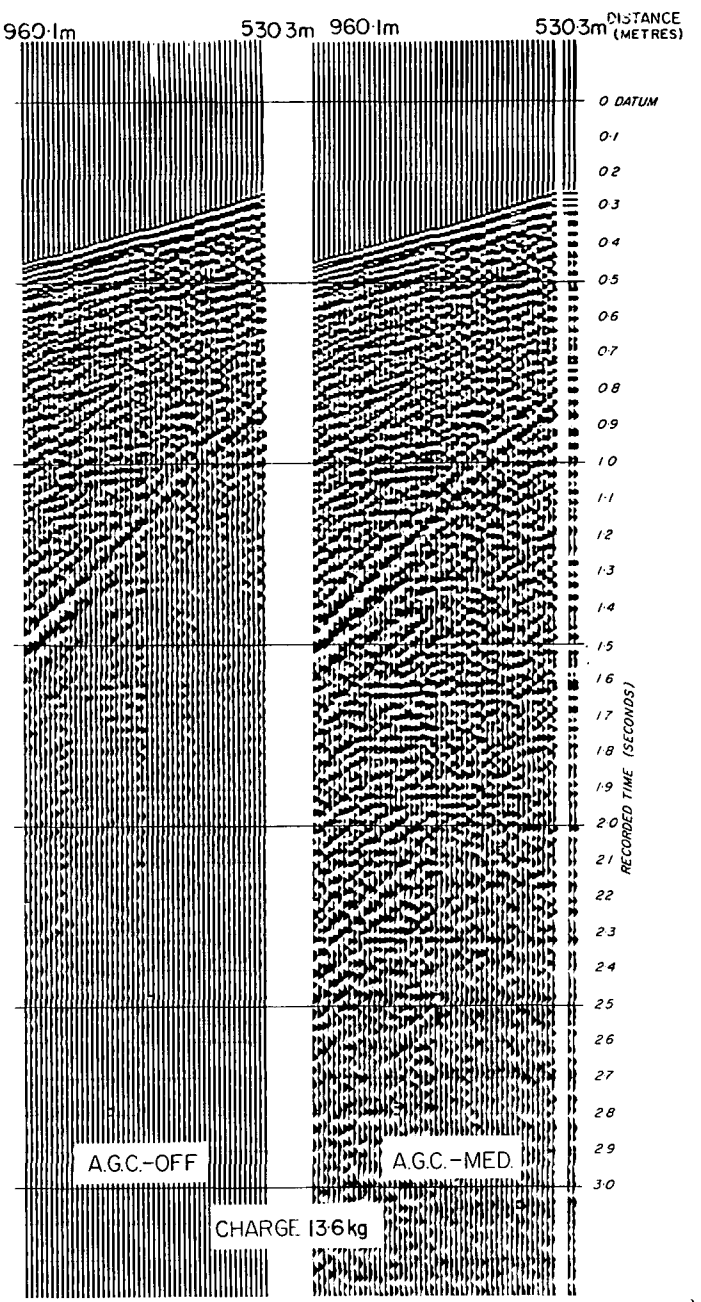
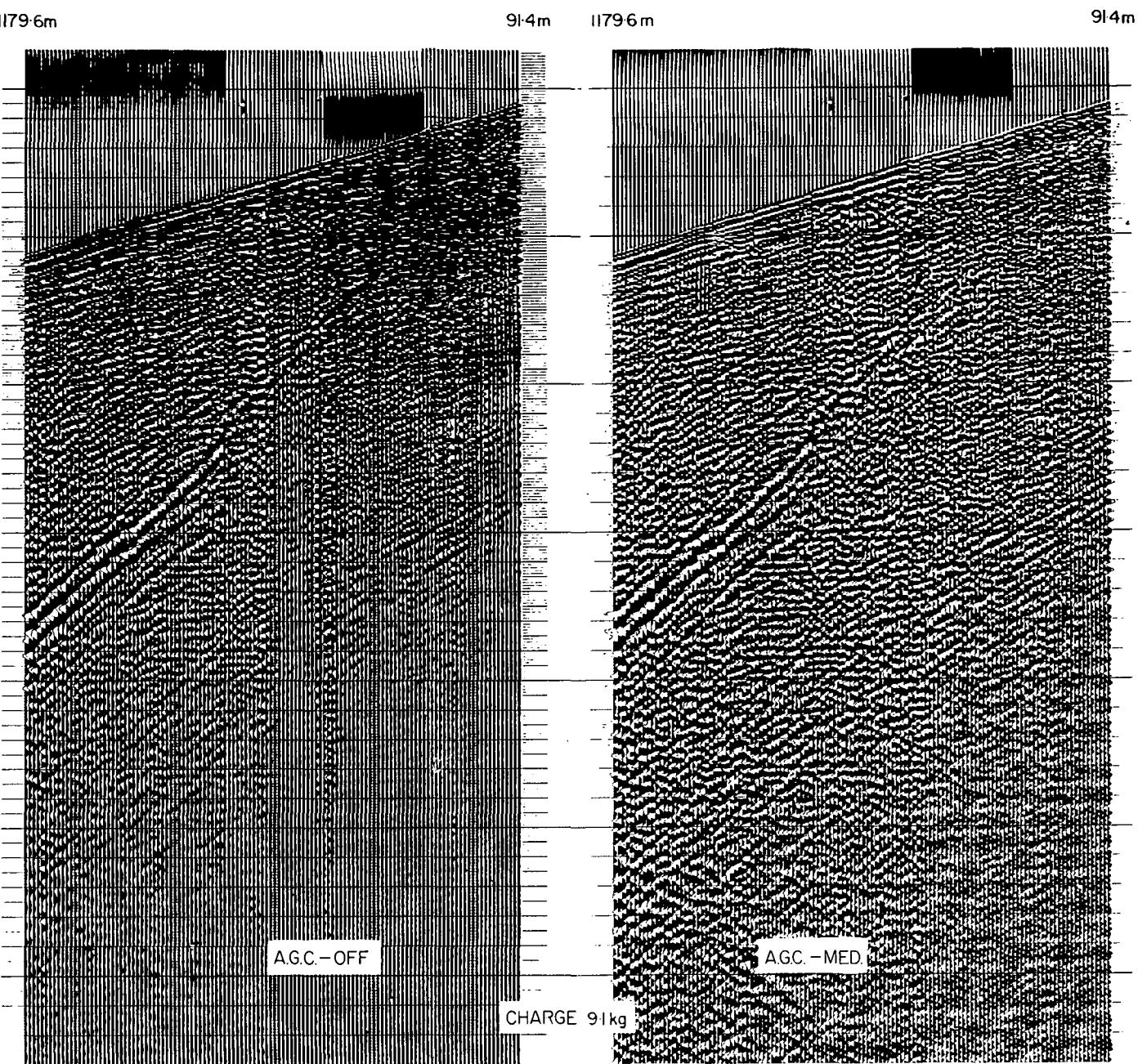
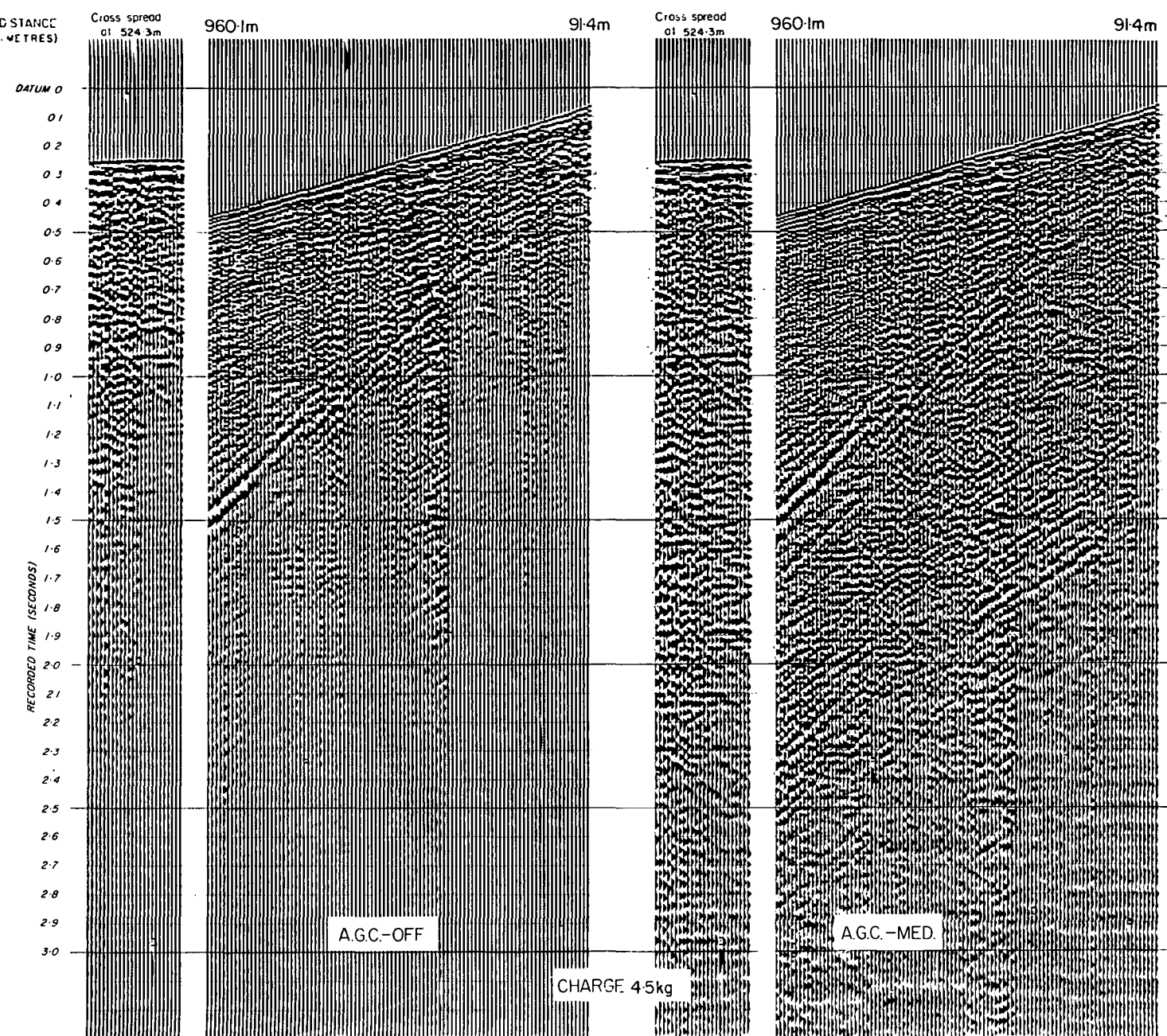
Longitudinal spreads-91m between traces
Transverse spreads-91m between traces

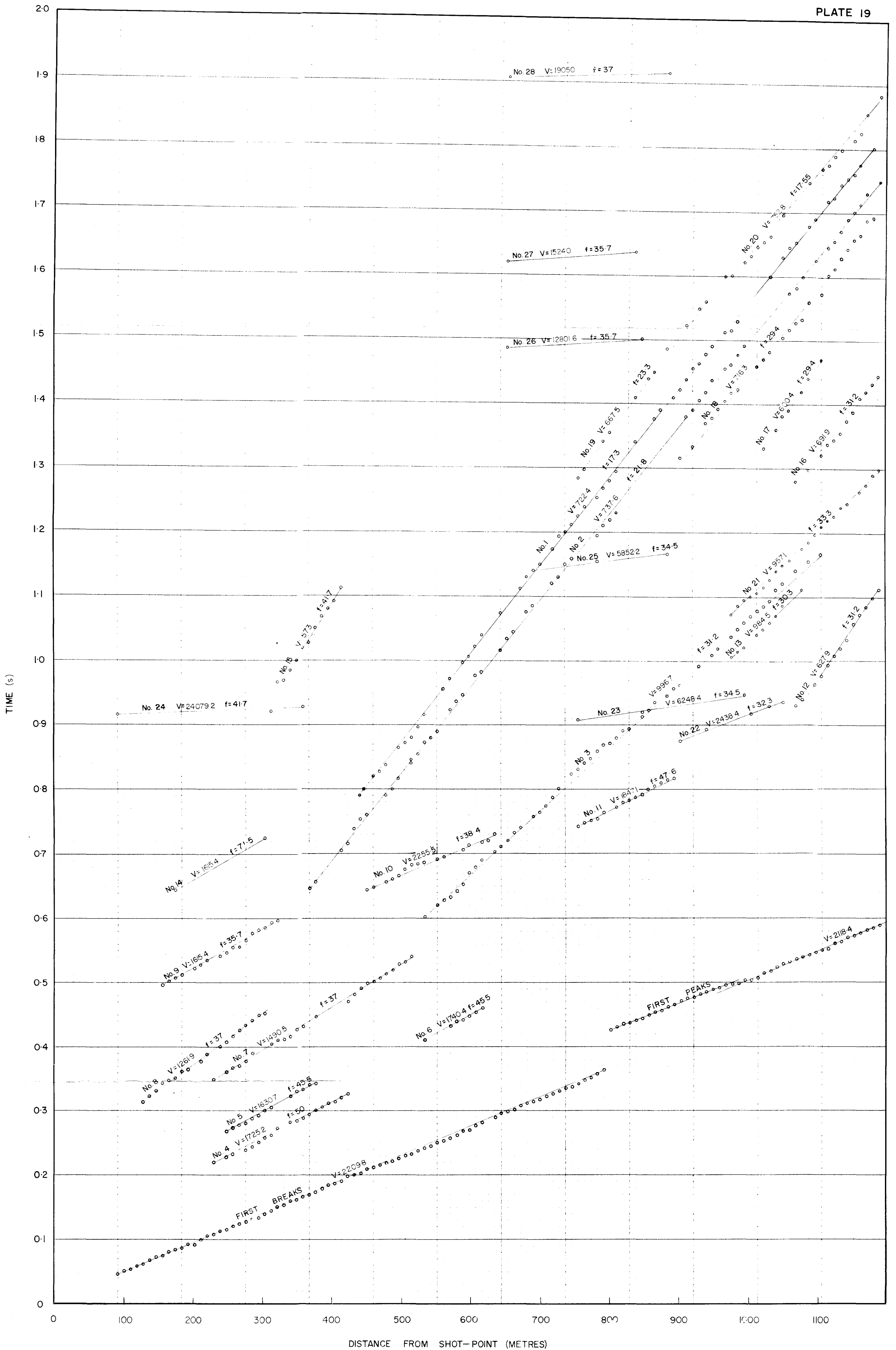
TRAVERSE GL2
NOISE ANALYSIS SP689

Record No. 1974/157

RECORDED BY : Seismic Party No. 2
SECTION BY : Bureau of Mineral Resources
Playback Centre SIE MS 42

J54/B3-15



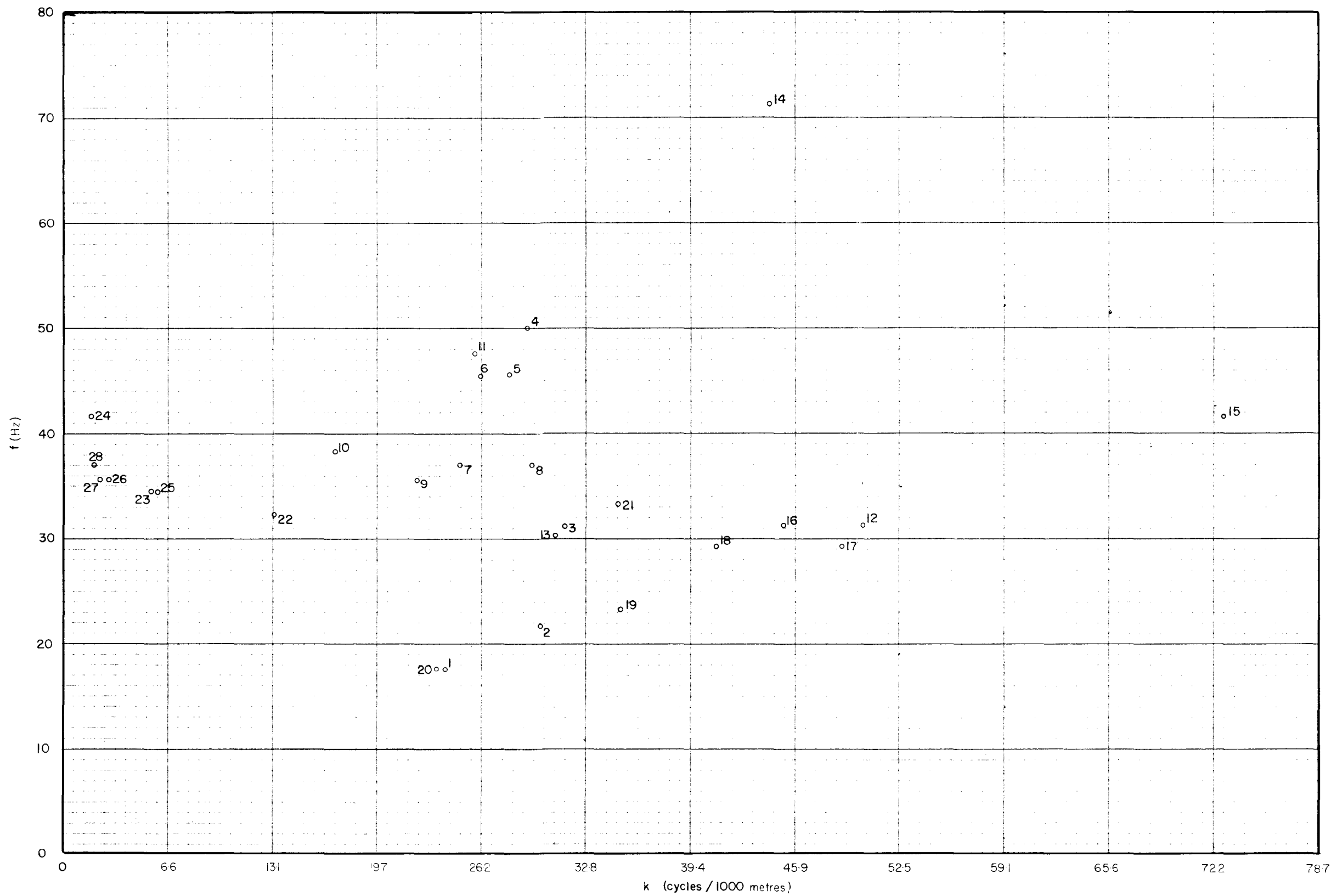
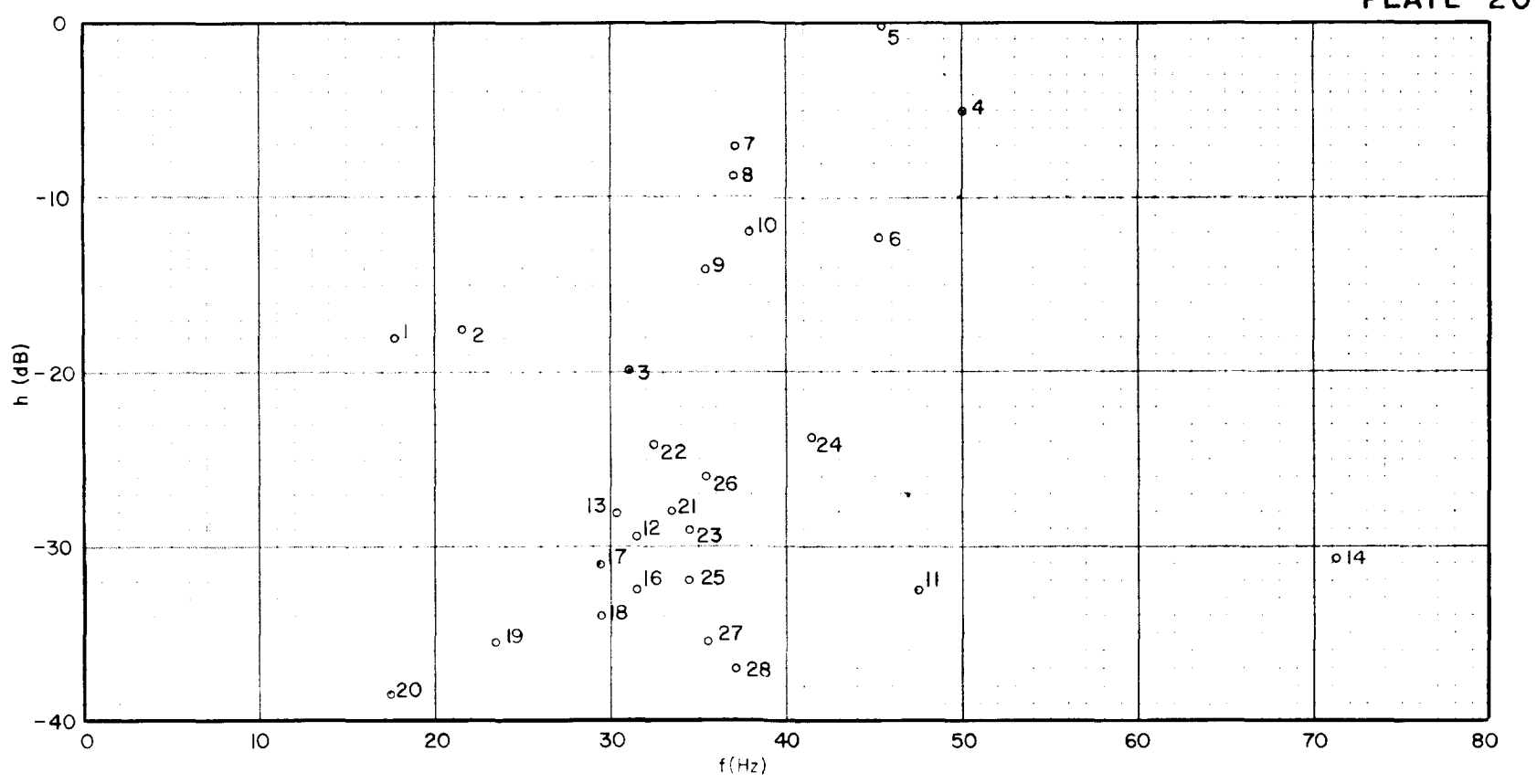
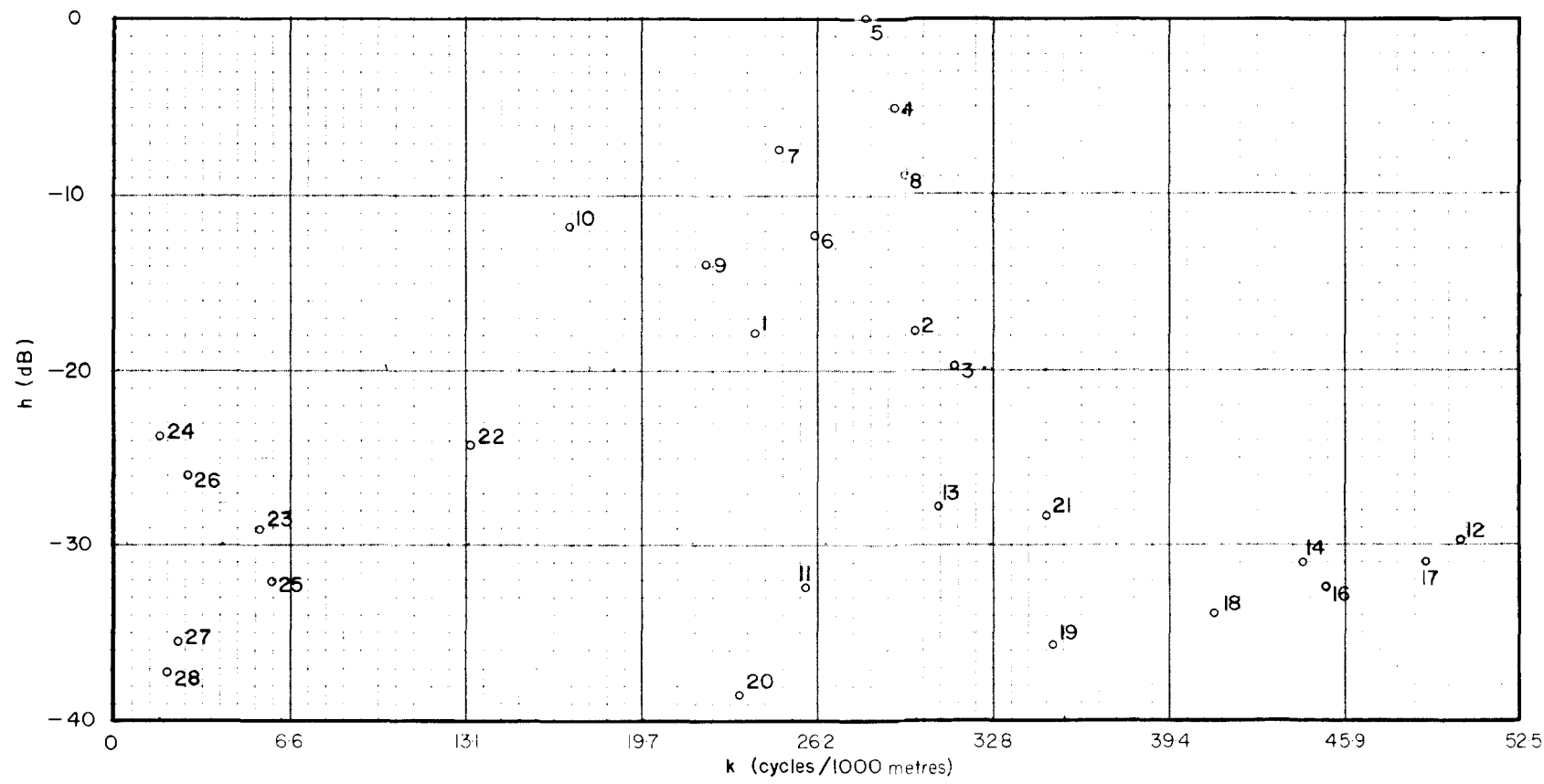


V=Velocity (m/s)
f=Estimated Peak Frequency (Hz)

DISTANCE FROM SHOT-POINT (METRES)

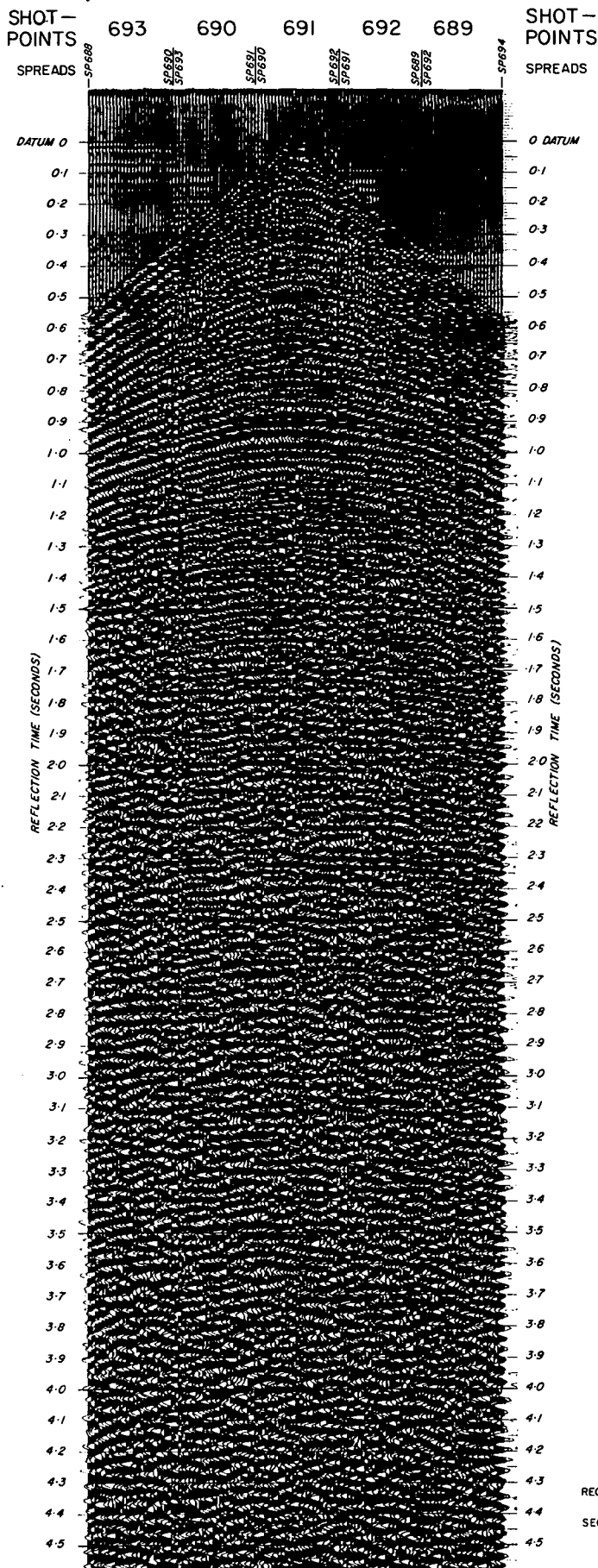
TRAVERSE GL2

NOISE ANALYSIS-SP 689



h = Relative Amplitude
k = Wave number
f = Frequency

TRAVERSE GL 2
NOISE ANALYSIS SP 689



CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: PREFILTERS 18 Hz, 12dB/O
KO-K92

A.G.C.: Med.

Gain Initial: -20

Final: -20

Geophones: HSJ-14 Hz

Geophone pattern:
48/trace, in 2 rows of 24 in line
Geophones 4.6m apart
Rows 9.1m apart

Shot-hole pattern:

7 holes, 15.2m apart in line

Depth 15.2/16.8m

Charge 7 x 94kg

PLAYBACK INFORMATION

Filters: 1/20-1/78

A.G.C.: Med.

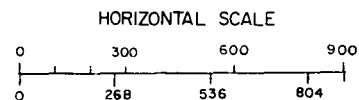
Gain Initial: -40

Final: -20

Trip delay: 0.5 to 1.5 s

Compositing: Nil

VELOCITY INFORMATION



Record No 1974/157

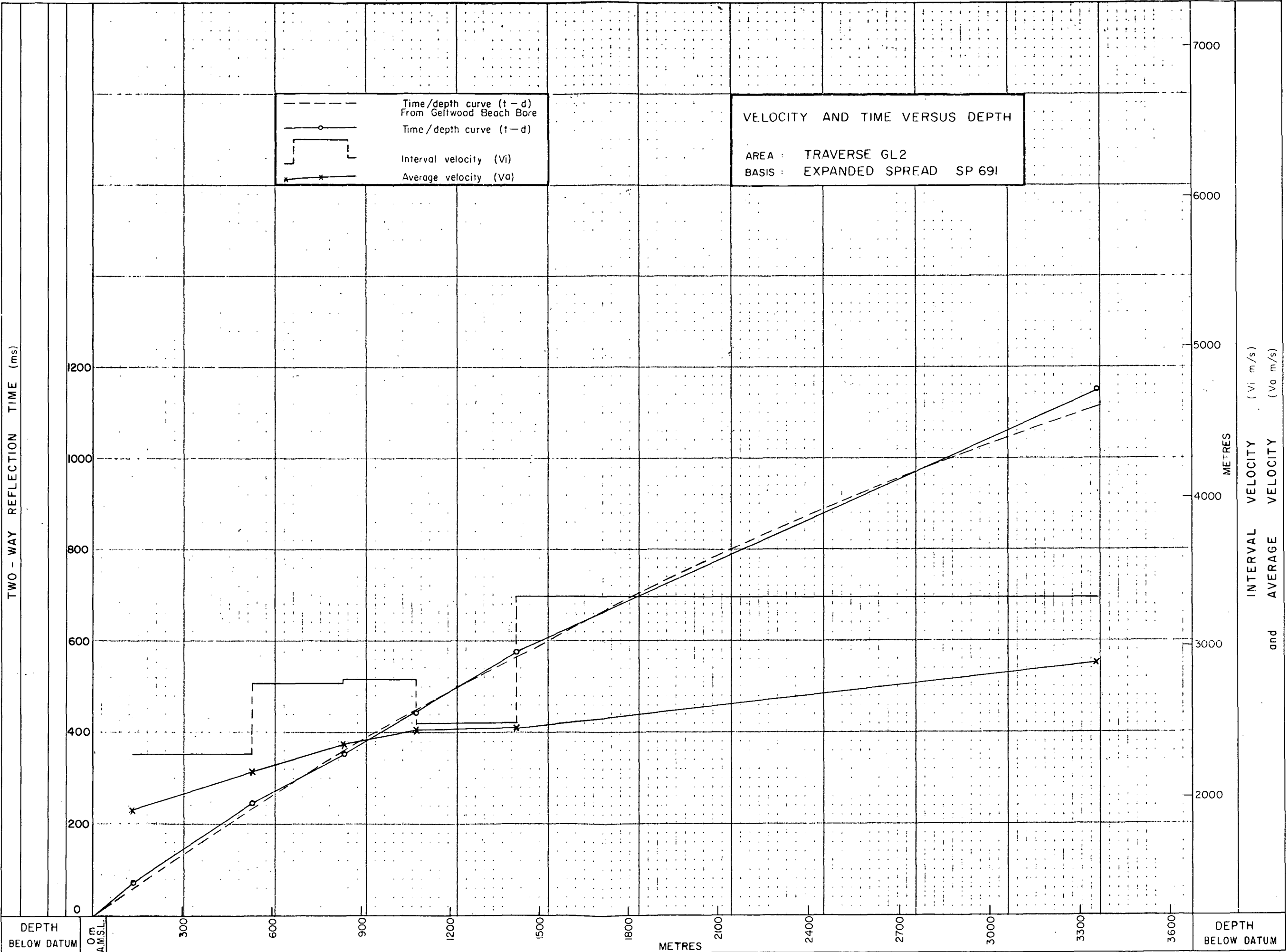
TRAVERSE GL2

EXPANDED SPREAD at SP691

RECORDED BY: Seismic Party No. 2

SECTION BY: Bureau of Mineral Resources
Playback Centre SIE MS 42

J54/B3-24 A



SHOT-
POINTS

693

693

693

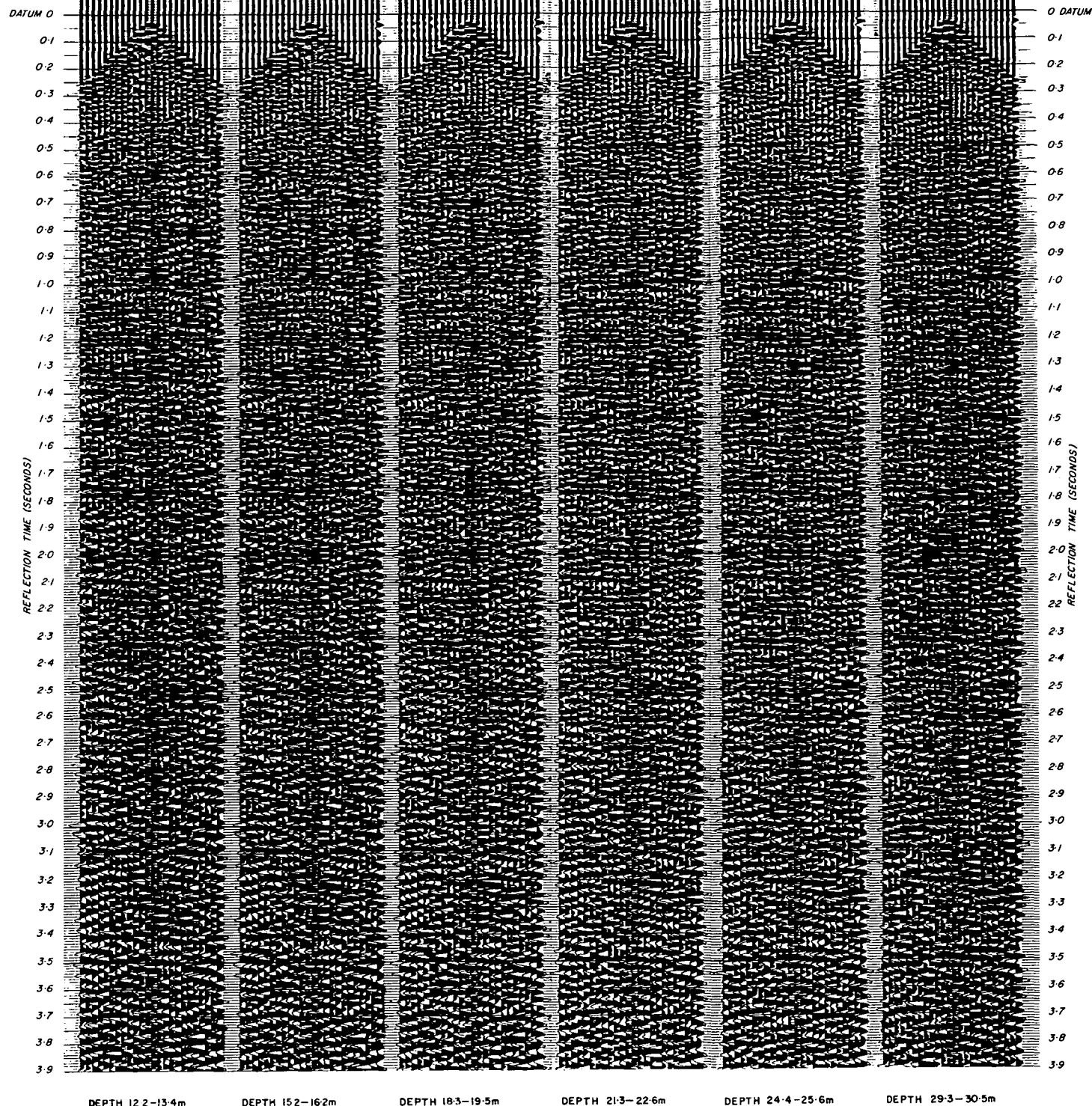
693

693

693

SHOT-
POINTS

UNCORRECTED PLATE 23 RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000B

Filters : Prefilters 18Hz, 12dB/o

KO-K92

A.G.C. : Med

Gain Initial : -60

Final : -10

Geophones : HJS-14Hz

Geophone pattern :

24/trace, 31m apart in line

Station interval 44.7m

Shot-hole pattern :

Single

Depth as indicated

Charge 4.5kg

PLAYBACK INFORMATION

Filters : 1/20-2/60

A.G.C. : Med

Gain Initial : -40

Final : -20

Trip delay : 0.5 s

Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Spread length 536.5m

TRAVERSE GL2

SP693

DEPTH COMPARISONS

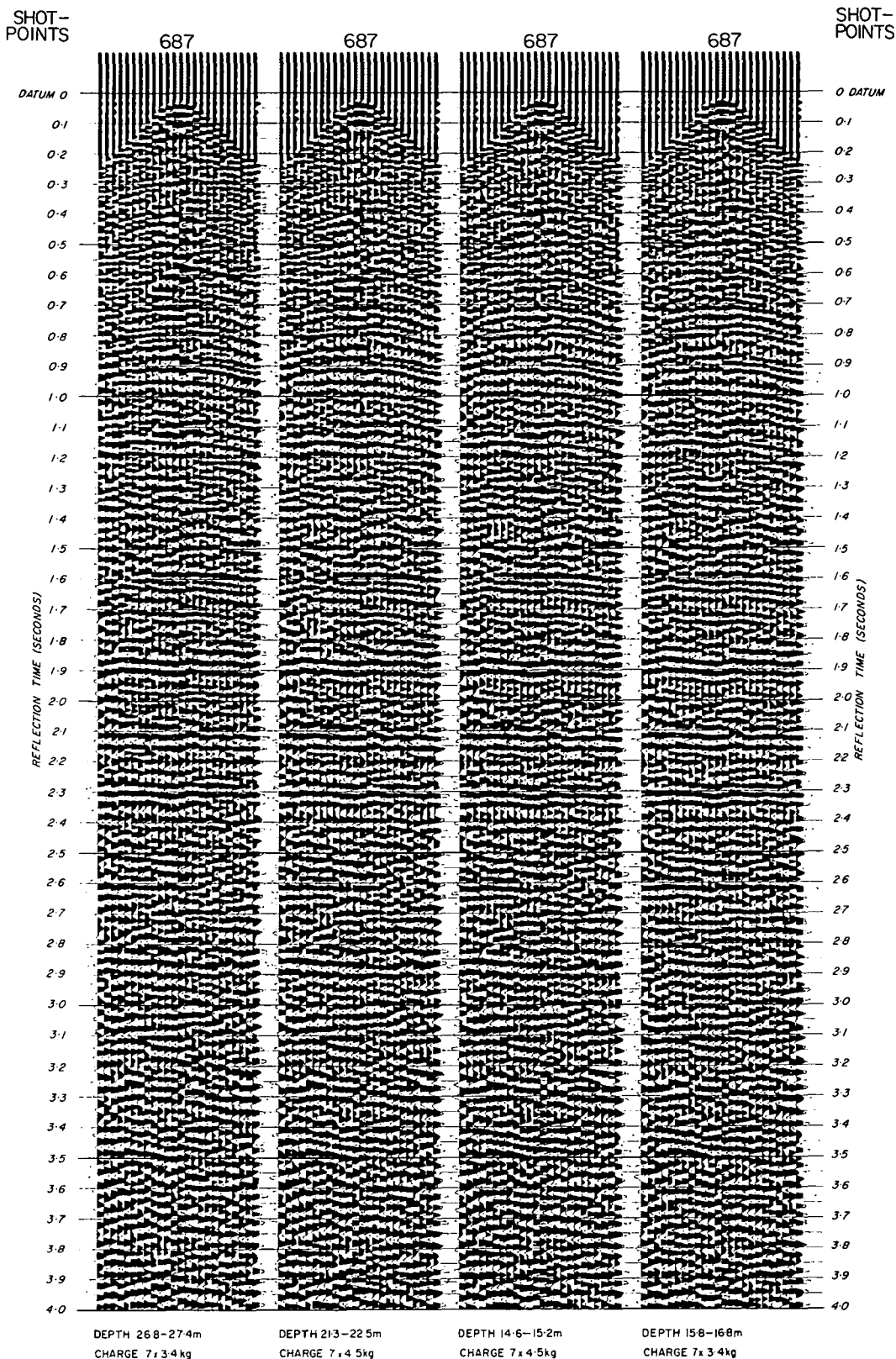
Record No. 1974/157

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources

Playback Centre SIE MS 42

J54/B3-32

UNCORRECTED
RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000 B

Filters : Prefilters 18 Hz, 12 dB/o
KO-K92

A.G.C. : Med

Gain Initial : -60

Final : -20

Geophones : HSJ-14 Hz

Geophone pattern :

48/trace, in 2 rows of 24 in line

Rows 9.1m apart

Geophones 3.1m apart

Station interval 44.7m

Shot-hole pattern :

7 holes, 12.2m apart in line

Depth } as indicated
Charge }

PLAYBACK INFORMATION

Filters : 1/20-2/60

A.G.C. : Med

Gain Initial : -40

Final : -20

Trip delay : 0.25 sec

Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Spread length 536.5m

TRAVERSE GL 2

SP 687

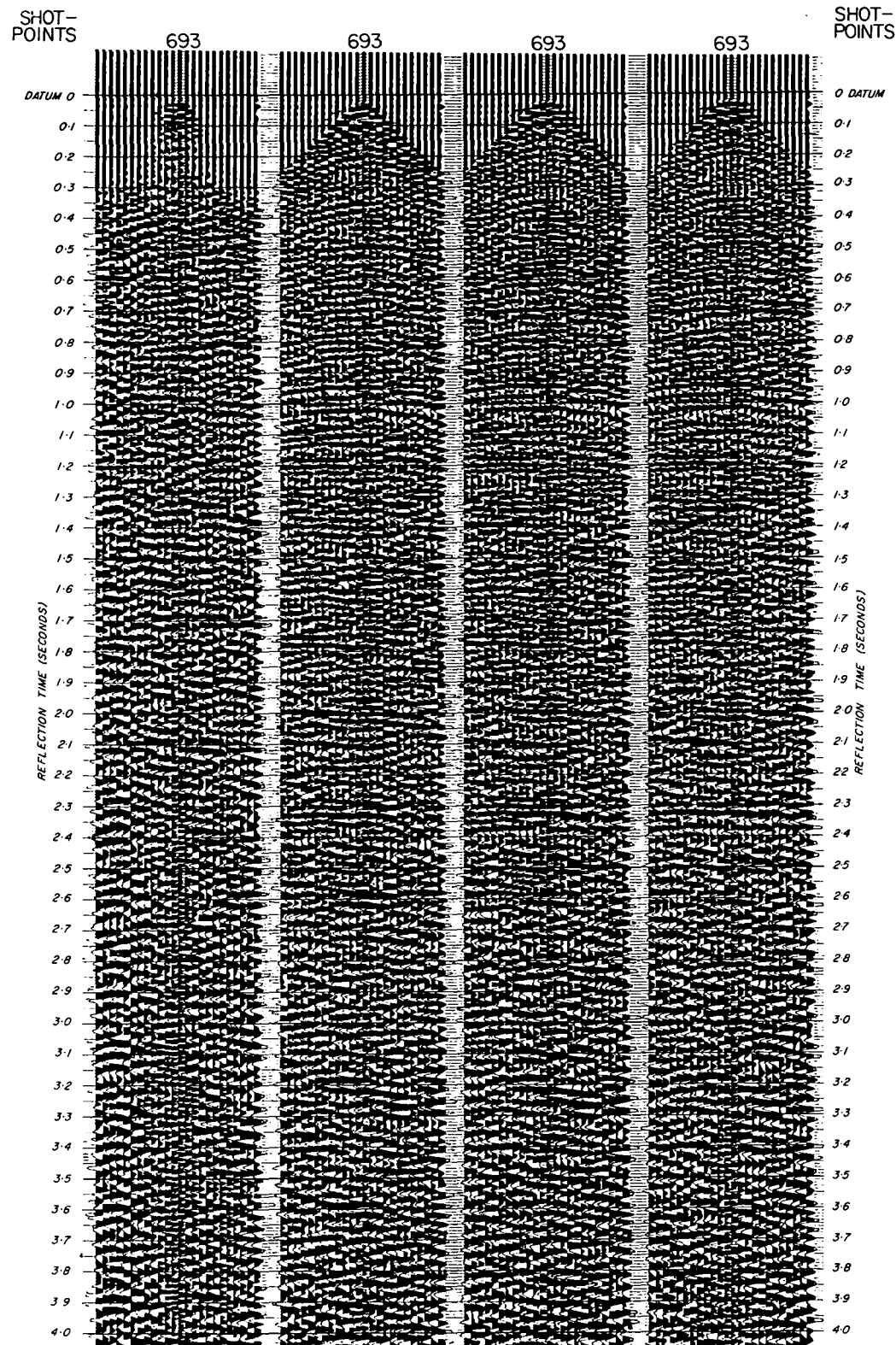
DEPTH AND CHARGE COMPARISONS

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources

Playback Centre SIE MS 42 J54/B3-30A

Record No. 1974/157



UNCORRECTED PLATE 25 RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000 B

Filters : Prefilters 18Hz, 12dB/o
K0-K92

A.G.C. : Med

Gain Initial : -60

Final : -10

Geophones : HSJ-14 Hz

Geophone pattern :

24 / trace, 3.1m apart in line

Station interval 44.7m

Shot-hole pattern :

As indicated

PLAYBACK INFORMATION

Filters : 1/20-2/60

A.G.C. : Med

Gain Initial : -40

Final : -20

Trip delay : 0.25s

Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Spread length 536.5

Record No 1974/157

TRAVERSE GL2

SP 693

SHOT-HOLE PATTERN COMPARISONS

5 HOLES, 15.2m APART IN LINE
DEPTH 3.1m
CHARGE 5X 6kg

3 HOLES, 15.2m APART IN LINE
DEPTH 15.2-16.8m
CHARGE 3X 4.5kg

5 HOLES, 15.2m APART IN LINE
DEPTH 15.8-16.2m
CHARGE 5X 2.3kg

5 HOLES, 15.2m APART IN LINE
DEPTH 16.5-16.8m
CHARGE 5X 1.2kg

RECORDED BY : Seismic Party No. 2

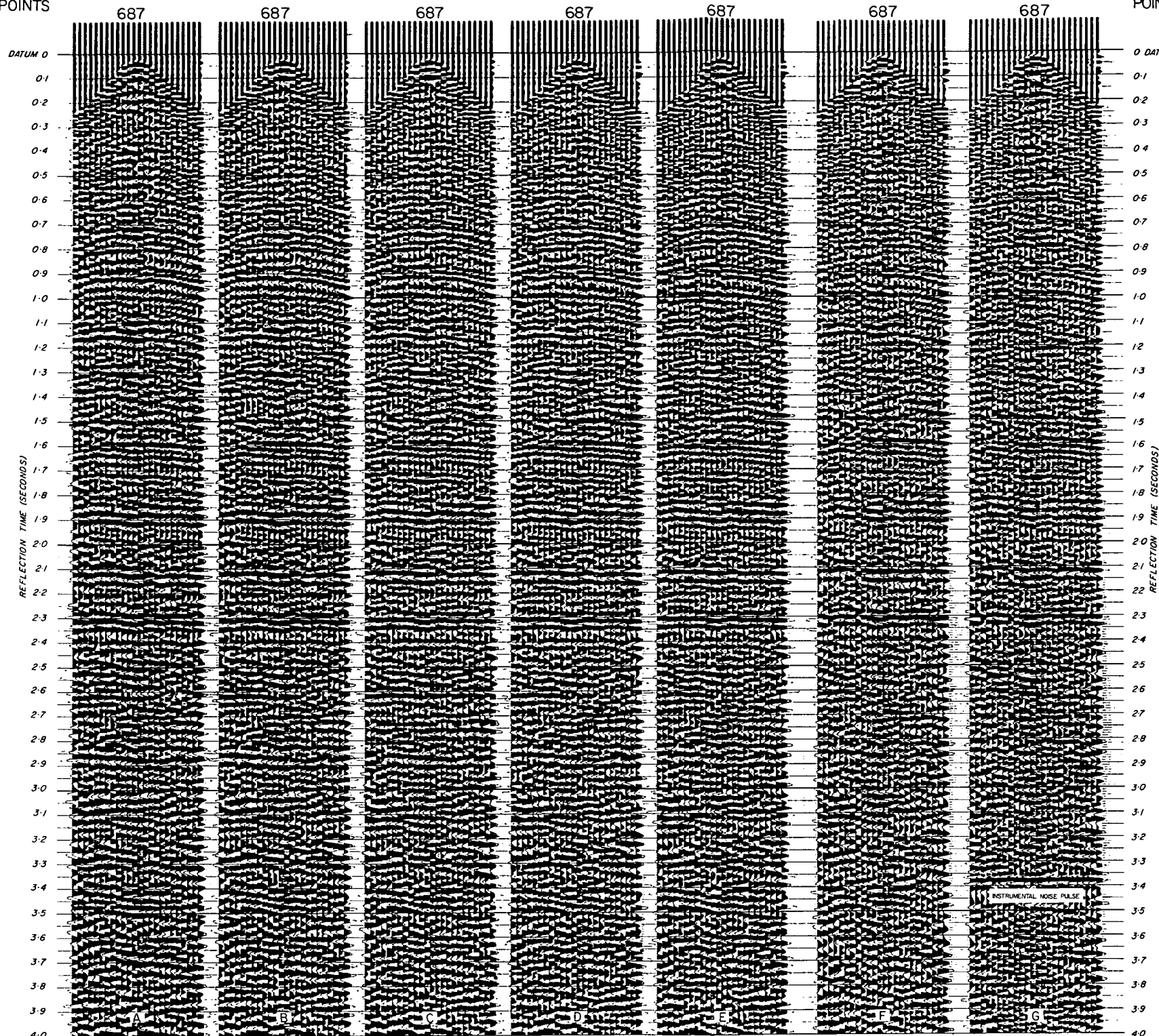
SECTION BY : Bureau of Mineral Resources

Playback Centre SIE MS 42 J54/B3-35

SHOT-
POINTS

SHOT-
POINTS

UNCORRECTED PLATE 26
RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder : PMR-20
Amplifiers : 7000 B
Filters : Prefilters 18Hz, 12dB/o
KO-K92
A.G.C. : Med
Gain Initial : -60
Final : -20
Geophones : HSJ-14 Hz
Geophone pattern :
As indicated
Station interval 44.7 m

Shot-hole pattern :
As indicated

PLAYBACK INFORMATION

Filters : 1/20-2/60
A.G.C. : Med
Gain Initial : -40
Final : -20
Trip delay : 0.5 s
Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE
Spread length 536.5 m

Record No. 1974/157

TRAVERSE GL 2

SP 687

GEOPHONE PATTERN, SHOT-HOLE PATTERN
AND CHARGE COMPARISON

GEOPHONE PATTERN
48 / TRACE IN 2 ROWS OF 24 IN LINE
ROWS 9.1 m APART
GEOPHONES 3.1 m APART
SHOT-HOLE PATTERN
7 HOLES, 12.2 m APART IN LINE
DEPTH 14.3 / 15.2 m
CHARGE 7 x 6.8 kg

GEOPHONE PATTERN
48 / TRACE IN 2 ROWS OF 24 IN LINE
ROWS 9.1 m APART
GEOPHONES 3.1 m APART
SHOT-HOLE PATTERN
7 HOLES, 12.2 m APART IN LINE
DEPTH 14.6 / 15.2 m
CHARGE 7 x 4.5 kg

GEOPHONE PATTERN
48 / TRACE IN 2 ROWS OF 24 IN LINE
ROWS 9.1 m APART
GEOPHONES 3.1 m APART
SHOT-HOLE PATTERN
7 HOLES, 12.2 m APART IN LINE
DEPTH 15.8 / 16.8 m
CHARGE 7 x 3.4 kg

GEOPHONE PATTERN
48 / TRACE IN 2 ROWS OF 24 IN LINE
ROWS 9.1 m APART
GEOPHONES 3.1 m APART
SHOT-HOLE PATTERN
5 HOLES, 15.2 m APART IN LINE
DEPTH 15.5 / 16.8 m
CHARGE 5 x 4.5 kg

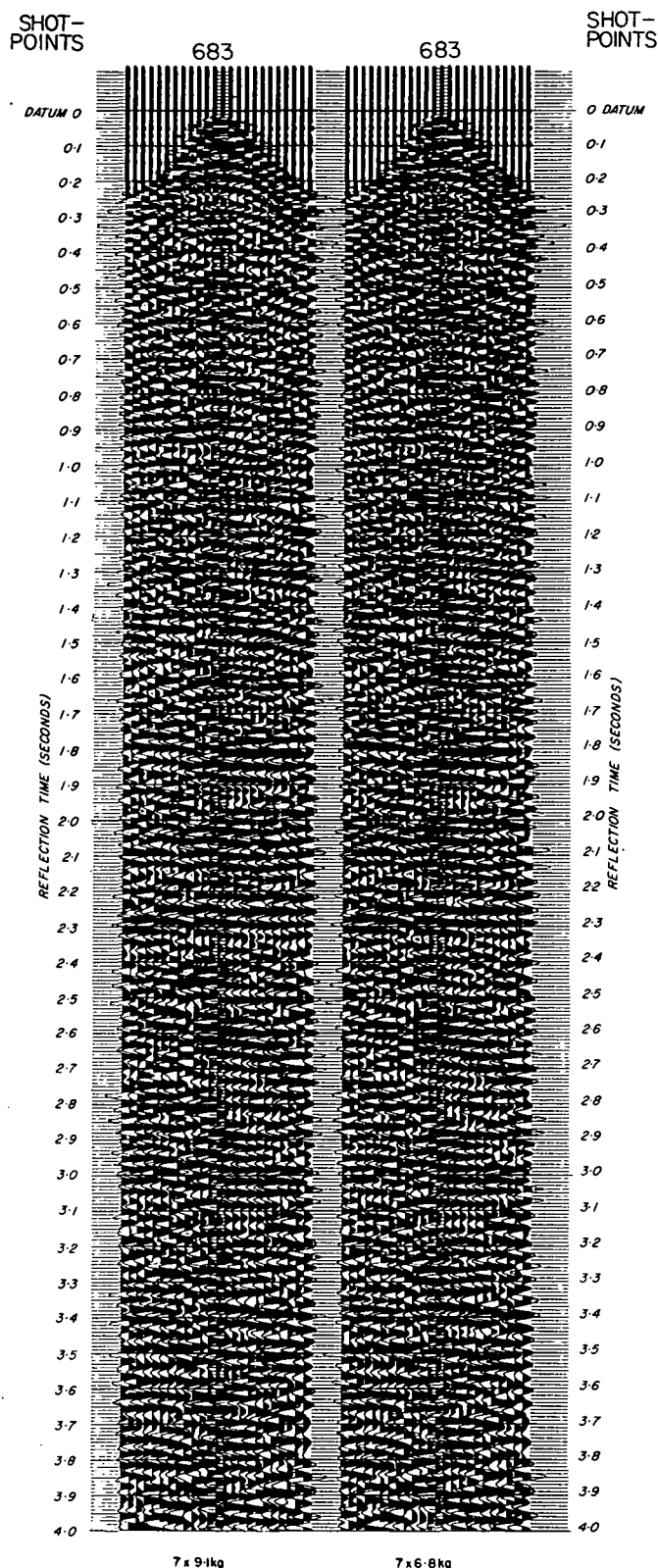
GEOPHONE PATTERN
48 / TRACE IN 2 ROWS OF 24 IN LINE
ROWS 9.1 m APART
GEOPHONES 3.1 m APART
SHOT-HOLE PATTERN
5 HOLES, 15.2 m APART IN LINE
DEPTH 16.2 / 16.8 m
CHARGE 5 x 2.3 kg

GEOPHONE PATTERN
24 / TRACE, 3.1 m APART IN LINE
SHOT-HOLE PATTERN
5 HOLES, 15.2 m APART IN LINE
DEPTH 15.5 / 16.8 m
CHARGE 5 x 4.5 kg

GEOPHONE PATTERN
24 / TRACE, 3.1 m APART IN LINE
SHOT-HOLE PATTERN
5 HOLES, 15.2 m APART IN LINE
DEPTH 16.2 / 16.8 m
CHARGE 5 x 2.3 kg

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources
Playback Centre SIE MS 42 J54/B3-34



UNCORRECTED
RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000 B

Filters : Prefilters 18 Hz, 12 dB/o
KO-K92

A.G.C. : Med

Gain Initial : -60

Final : -20

Geophones : HSJ-14 Hz

Geophone pattern :

48/trace in 2 rows of 24 in line

Rows 9.1m apart

Geophones 3.1m apart

Station Interval 44.7m

Shot-hole pattern :

7 Holes, 12.2m apart in line

Depth 15.2-16.8m

Charge as indicated

PLAYBACK INFORMATION

Filters : 1/20-2/60

A.G.C. : Med

Gain Initial : -40

Final : -20

Trip delay : 0.5 s

Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Spread length 536.5m

TRAVERSE GL2

SP 683

CHARGE COMPARISON

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources

Playback Centre SIE MS 42 J54/B3-33A

Record No 1974/157

SHOT-POINTS

685

687

685

687

685

687

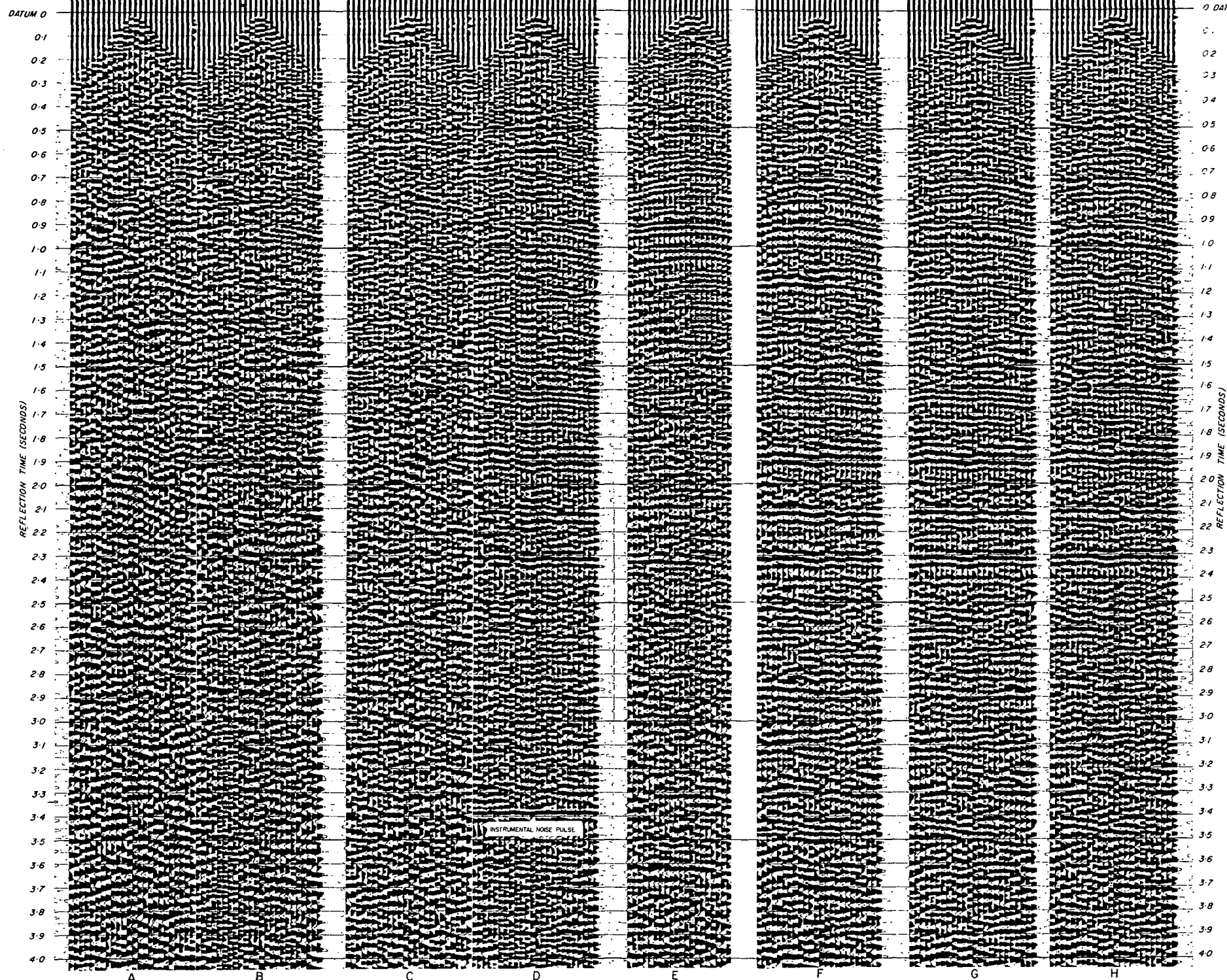
687

687

SHOT-POINTS

UNCORRECTED
RECORD SECTION

PLATE 28



GEOPHONE PATTERN
24/TRACE, 3.1m APART IN LINE
SHOT-HOLE PATTERN
18 HOLES, IN 3 ROWS OF 6 IN LINE
ROWS 12.2m APART
HOLES 12.2m APART
DEPTH 5.5m
CHARGE 18X1.2 kg.

GEOPHONE PATTERN
24/TRACE, 3.1m APART IN LINE
SHOT-HOLE PATTERN
5 HOLES, 15.2m APART IN LINE
DEPTH 16.2/16.8m
CHARGE 5X2.3 kg

GEOPHONE PATTERN
48/TRACE IN 2 ROWS OF 24 IN LINE
ROWS 9.1m APART
GEOPHONES 3.1m APART
SHOT-HOLE PATTERN
7 HOLES, 12.2m APART IN LINE
DEPTH 14.3/15.2m
CHARGE 7X6.8 kg

GEOPHONE PATTERN
48/TRACE IN 2 ROWS OF 24 IN LINE
ROWS 9.1m APART
GEOPHONES 3.1m APART
SHOT-HOLE PATTERN
5 HOLES, 15.2m APART IN LINE
DEPTH 15.5/16.8m
CHARGE 5X4.5 kg

GEOPHONE PATTERN
48/TRACE IN 2 ROWS OF 24 IN LINE
ROWS 9.1m APART
GEOPHONES 3.1m APART
SHOT-HOLE PATTERN
10 HOLES, IN 2 ROWS OF 5 IN LINE
ROWS 12.2m APART
HOLES 15.2m APART
DEPTH 15.8m/16.2m
CHARGE 10X2.3 kg

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000 B

Filters : Prefilters 18 Hz, 12 dB/o
KO-K92

A.G.C. : Med

Gain Initial : -60

Final : -20

Geophones : HSJ-14 Hz

Geophone pattern :

As indicated

Station interval 44.7 m

Shot-hole pattern :

As indicated

PLAYBACK INFORMATION

Filters : 1/20-2/60

A.G.C. : Med

Gain Initial : -40

Final : -20

Trip delay : 0.5s

Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Spread length 536.5 m

TRAVERSE GL2

SP685 AND SP687

SHOT-HOLE PATTERN COMPARISONS

Record No 1974/157

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources

Playback Centre SIE MS 42 J54/B3-36

SHOT-
POINTS

691

693

691

693

691

693

SHOT-
POINTSUNCORRECTED
RECORD SECTION **PLATE 29**

DATUM 0

0.1

0.2

0.3

0.4

0.5

0.6

0.7

0.8

0.9

1.0

1.1

1.2

1.3

1.4

1.5

REFLECTION TIME (SECONDS)

1.6

1.7

1.8

1.9

2.0

2.1

2.2

2.3

2.4

2.5

2.6

2.7

2.8

2.9

3.0

3.1

3.2

3.3

3.4

3.5

3.6

3.7

3.8

3.9

4.0

0 DATUM

0.1

0.2

0.3

0.4

0.5

0.6

0.7

0.8

0.9

1.0

1.1

1.2

1.3

1.4

1.5

1.6

1.7

1.8

1.9

2.0

2.1

2.2

2.3

2.4

2.5

2.6

2.7

2.8

2.9

3.0

3.1

3.2

3.3

3.4

3.5

3.6

3.7

3.8

3.9

4.0

REFLECTION TIME (SECONDS)

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000 B

Filters : Prefilters 18 Hz, 12 dB/o
KO - K92

A.G.C. : Med

Gain Initial : -60

Final : -20

Geophones : HSJ-14 Hz

Geophone pattern :

48/trace, in 2 rows of 24 in line

Rows 9.1m apart

Geophones 3.1m apart

Station interval 44.7m

Shot-hole pattern :

As indicated

PLAYBACK INFORMATION

Filters : 1/20-2/60

A.G.C. : Med

Gain Initial : -40

Final : -20

Trip delay : 0.5s

Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Spread length 536.5 m

TRAVERSE GL2

SP 691 AND 693

SHOT-HOLE PATTERN COMPARISONS

9 HOLES, 12.2m APART IN LINE
DEPTH 15.2-16.5m
CHARGE 9X6-8 kg7 HOLES, 15.2m APART IN LINE
DEPTH 15.2-17.1m DEPTH 14.6-17.1m
CHARGE 7X9-1 kg7 HOLES, 12.2m APART IN LINE
DEPTH 15.2-16.5m DEPTH 16.2-17.1m
CHARGE 7X9-1 kg

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources

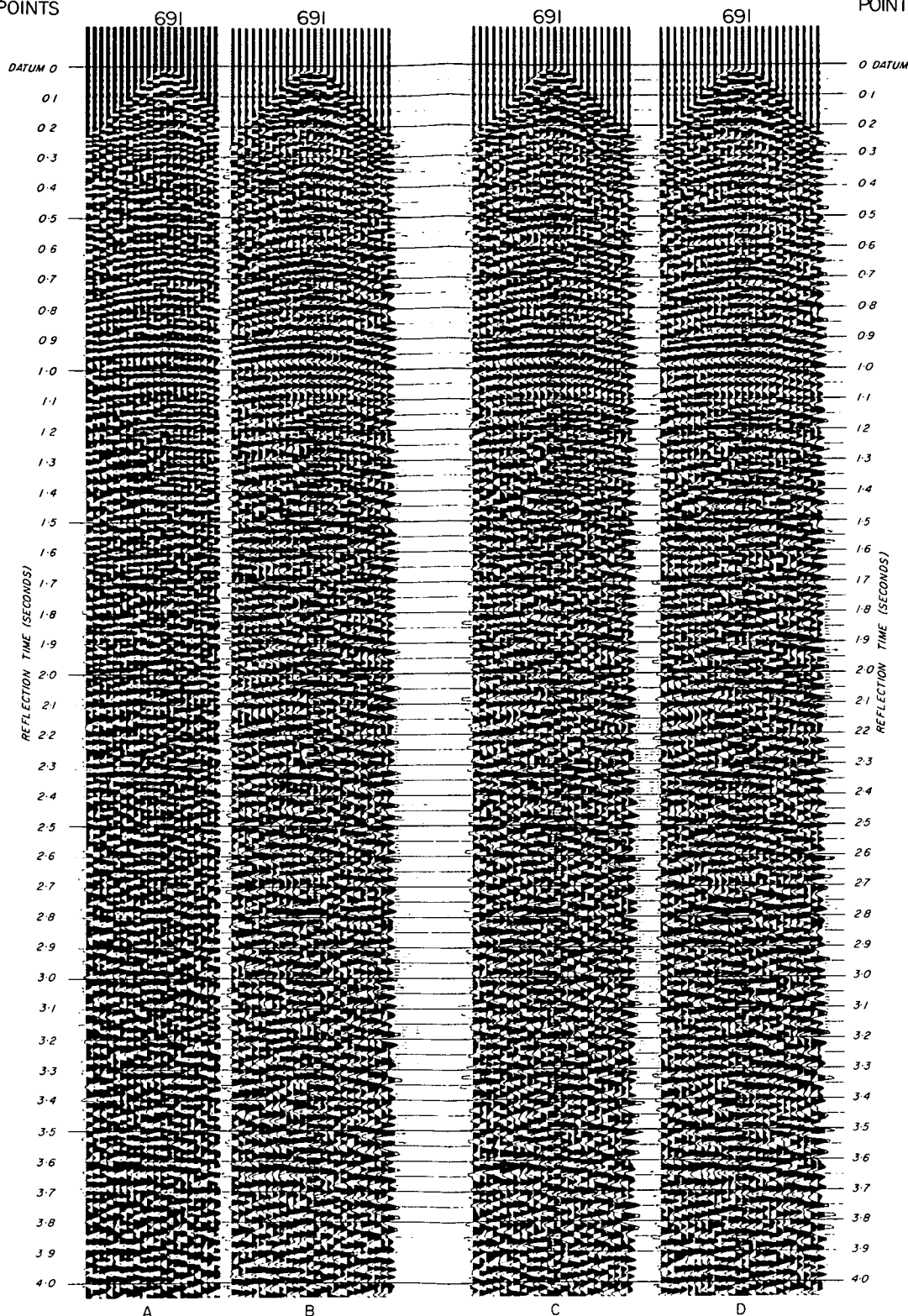
Playback Centre SIE MS 42 J54/B3-27

Record No. 1974/157

SHOT-
POINTS

SHOT-
POINTS

UNCORRECTED RECORD SECTION PLATE 30



RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000 B

Filters : Prefilters 18 Hz, 12 dB/o
KO-K92

A.G.C. : Med

Gain Initial : -60

Final : -20

Geophones : HSJ-14 Hz

Geophone pattern :

As indicated

Station interval 44.7 m

Shot-hole pattern :

As indicated

PLAYBACK INFORMATION

Filters : 1/20 - 2/60

A.G.C. : Med

Gain Initial : -40

Final : -20

Trip delay : 0.5s

Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Spread length 536.5 m

Record No. 1974/157

TRAVERSE GL2

SP 691

GEOPHONE PATTERN COMPARISONS

GEOPHONE PATTERN
48/TRACE, IN 2 ROWS OF 24 IN LINE
ROWS 9.1m APART
GEOPHONES 3.1m APART
SHOT-HOLE PATTERN
9 HOLES, 12.2m APART IN LINE
DEPTH 15.5-17.1m
CHARGE 9X6.8kg

GEOPHONE PATTERN
48/TRACE, IN 2 ROWS OF 24 IN LINE
ROWS 9.1m APART
GEOPHONES 4.6m APART
SHOT-HOLE PATTERN
9 HOLES, 12.2m APART IN LINE
DEPTH 15.5-17.1m
CHARGE 9X6.8kg

GEOPHONE PATTERN
48/TRACE, IN 2 ROWS OF 24 IN LINE
ROWS 9.1m APART
GEOPHONES 3.1m APART
SHOT-HOLE PATTERN
7 HOLES, 15.2m APART IN LINE
DEPTH 15.5-17.1m
CHARGE 7X9.1kg

GEOPHONE PATTERN
48/TRACE, IN 2 ROWS OF 24 IN LINE
ROWS 9.1m APART
GEOPHONES 4.6m APART
SHOT-HOLE PATTERN
7 HOLES, 15.2m APART IN LINE
DEPTH 15.5-17.1m
CHARGE 7X9.1kg

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources

Playback Centre SIE MS 42 J54/B3-28

SHOT-POINTS 675 676 1/2 678 679 1/2 681

SHOT-POINTS

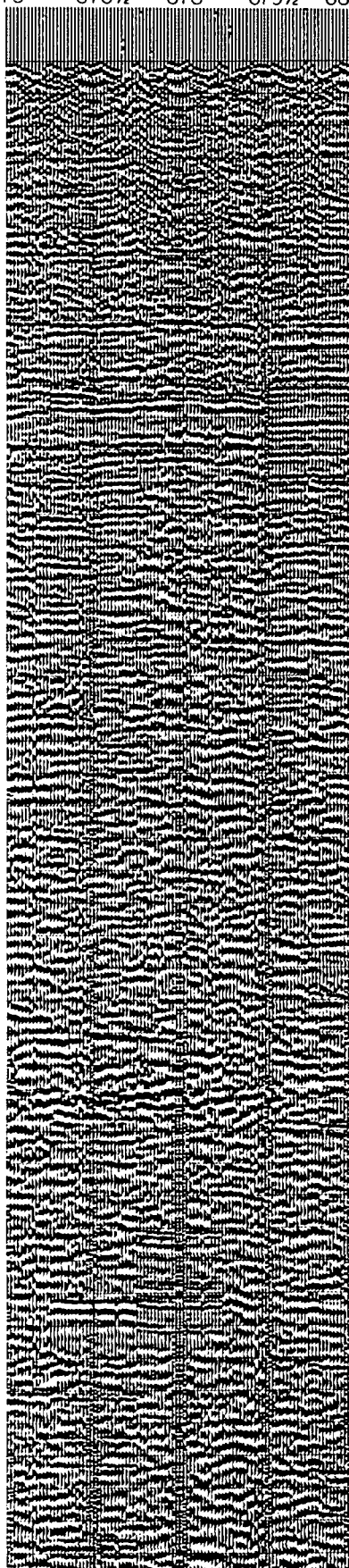
CORRECTED RECORD SECTION

P L A T E 31

DATUM 0

0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4.0
4.1
4.2
4.3
4.4
4.5

REFLECTION TIME (SECONDS)



0 DATUM

0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4.0
4.1
4.2
4.3
4.4
4.5

REFLECTION TIME (SECONDS)

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: PREFILTERS 18Hz, 12db/o
KO-K92

A.G.C.: Med.

Gain Initial: -60

Final: -20

Geophones: HSJ-14 Hz

Geophone pattern:

48/trace, in 2 rows of 24 in line

Geophones 4.6m apart

Rows 91m apart

Station interval 335m

Shot-hole pattern:

7 holes, 15.2m apart in line

Depth 15.2/16.8m

Charge 7 x 9.1kg

PLAYBACK INFORMATION

Filters: 1/20-2/60

A.G.C.: Med.

Gain Initial: -40

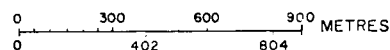
Final: -20

Trip delay: 0.5s

Compositing: Nil

VELOCITY INFORMATION

Expanded spread at SP691



TRAVERSE GL2

SP675- SP681

RECORDED BY: Seismic Party No. 2

SECTION BY: Bureau of Mineral Resources
Playback Centre SIE MS 42

Record No 1974/157

J54/B3-29A

CORRECTED
RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: PMR 20
Amplifiers: 7000B
Filters: PREFILTERS 18Hz, 12db/O
A.G.C.: Med. KO-K92
Gain Initial: -60
Final: -20
Geophones: HSJ-14 Hz
Geophone pattern:
48/trace in 2 rows of 24 in line
Rows 9m apart
Geophones 3.1m apart
Station interval 44.7m
Shot-hole pattern:
SP 693 and 691
7 holes 12.2m apart in line 9 holes 12.2m apart in line
Depth 15.2/16.5m Depth 15.2/16.5m
Charge 7x6.8kg Charge 9x16.8kg
Ex. SP 681, 683, 689 - 7x9.1kg

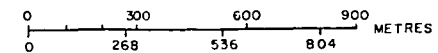
PLAYBACK INFORMATION

Filters: 1/20 - 2/60
A.G.C.: Med.
Gain Initial: -40
Final: -20
Trip delay: 0.5 s
Compositing: Nil

VELOCITY INFORMATION

1st analysis

HORIZONTAL SCALE



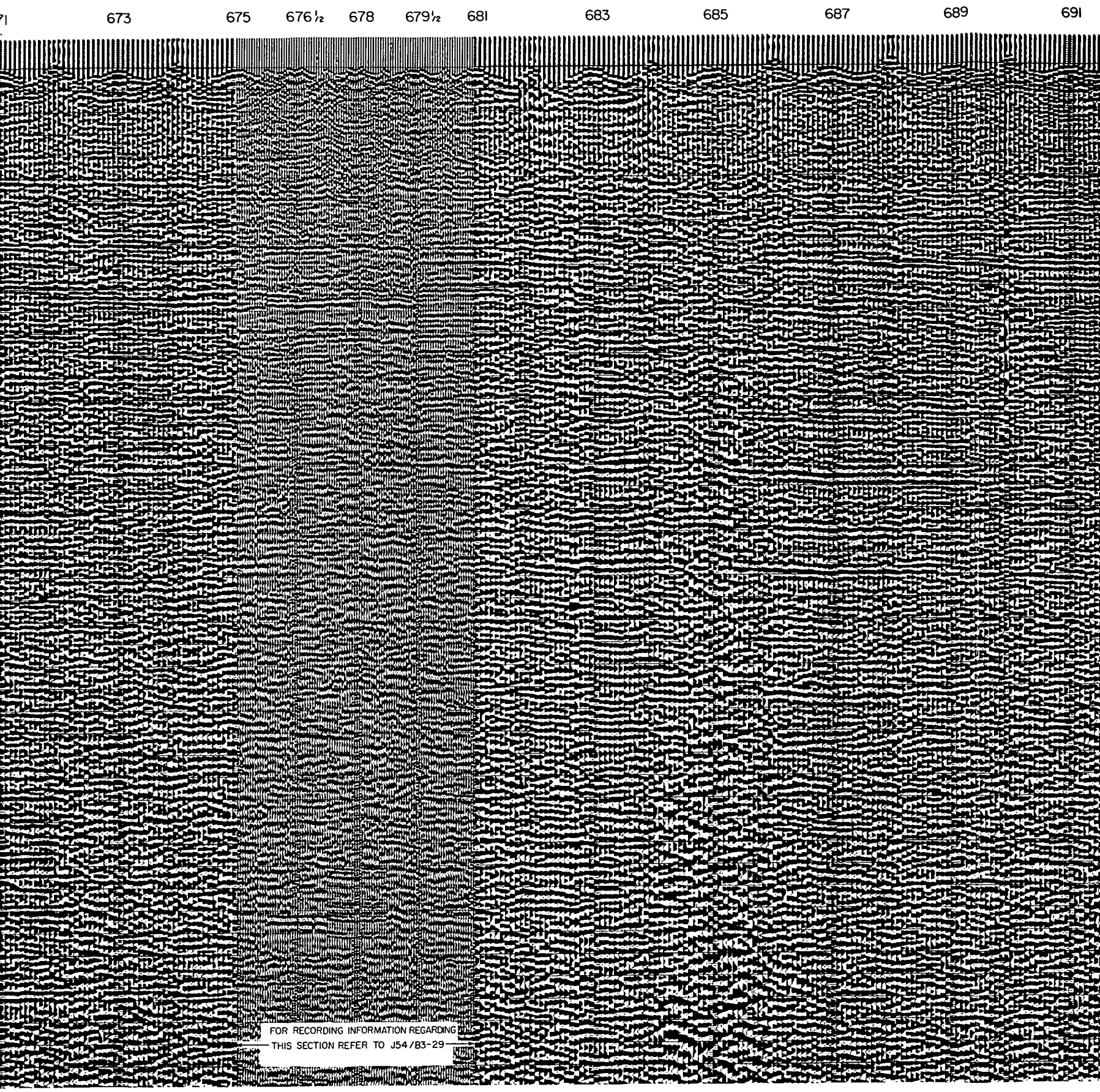
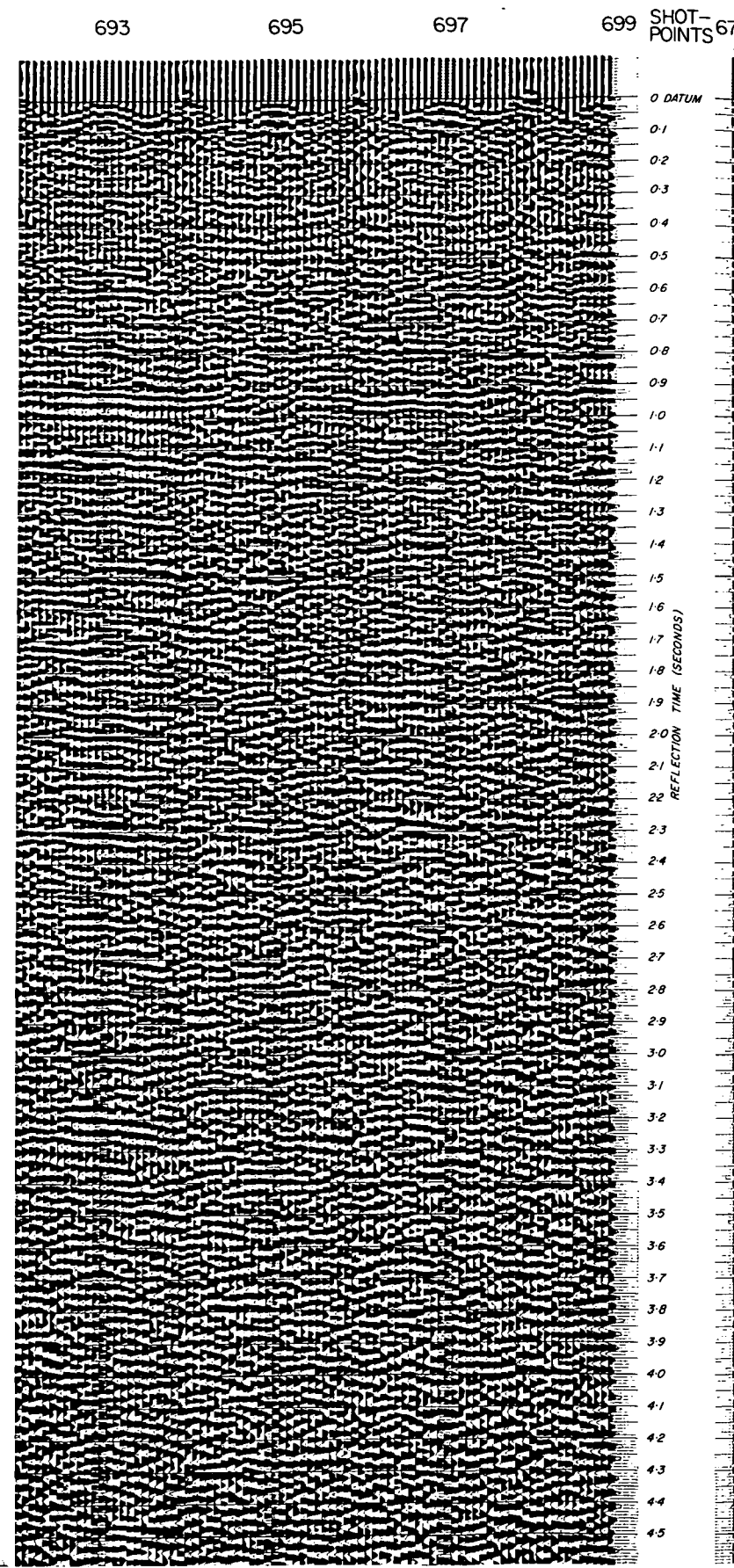
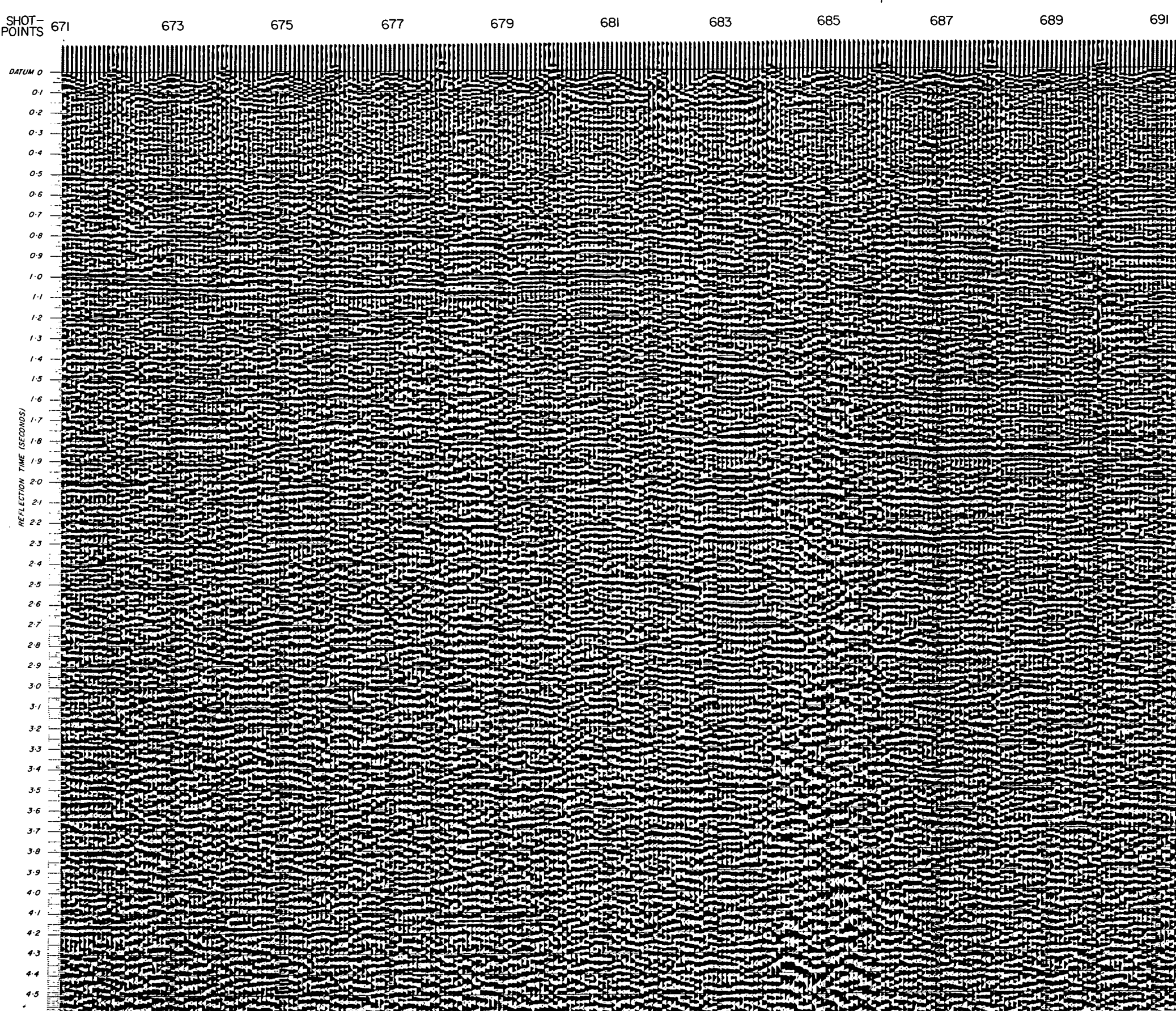
Record No. 1974 / 157

TRAVERSE GL 2

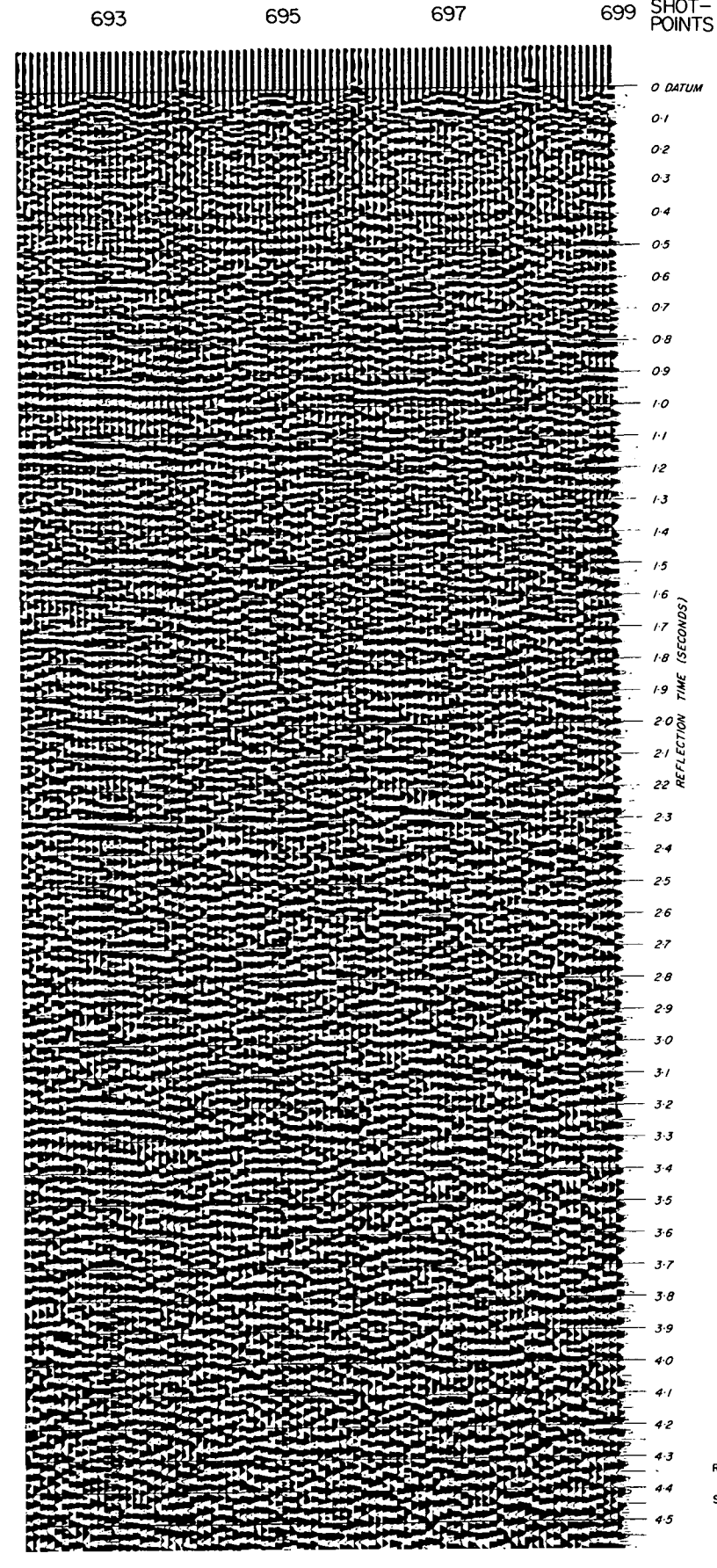
SP 671 - SP 699

RECORDED BY: Seismic Party No. 2

SECTION BY: Bureau of Mineral Resources
Playback Centre SIE MS 42 J54/B3-40

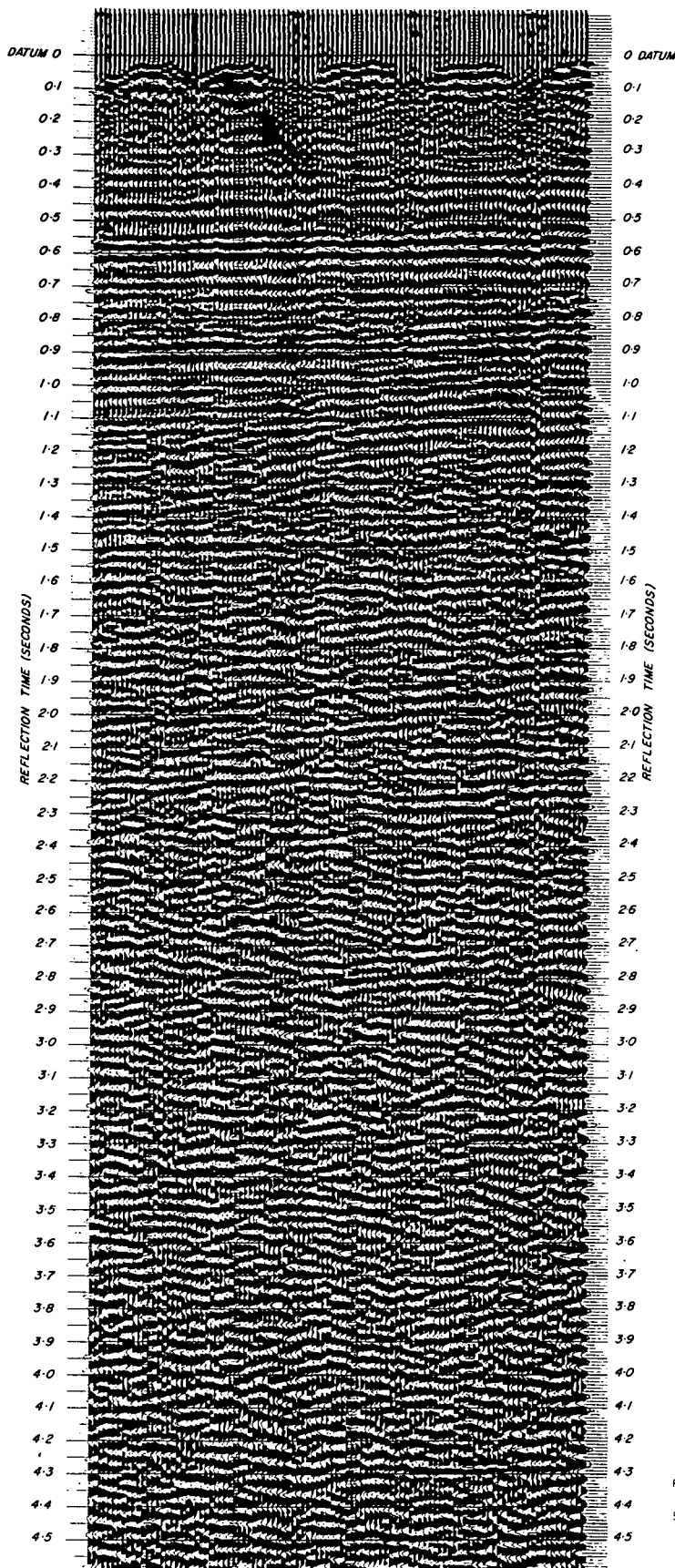


FOR RECORDING INFORMATION REGARDING
THIS SECTION REFER TO J54/B3-29



CORRECTED RECORD SECTION

SHOT-POINTS 896 1/4 897 898 899 900 SHOT-POINTS



RECORDING INFORMATION

Magnetic Recorder: PMR20

Amplifiers: 7000B

Filters: PREFILTERS 18Hz, 12dB/O
K0-K92

A.G.C.: Med.

Gain Initial: -60

Final: -20

Geophones: HSJ-14Hz

Geophone pattern:

48/traces in 2 rows of 24 in line

Rows 9.1m apart

Geophones 4.6m apart

Station interval 335m

Shot-hole pattern:

7 holes, 12.5m apart in line

Depth 15.8/18.3m

Charge 7 x 94kg

PLAYBACK INFORMATION

Filters: 1/20 - 2/60

A.G.C.: Med.

Gain Initial: -40

Final: -20

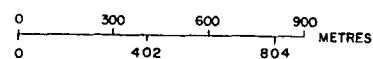
Trip delay: 0.5s

Compositing: Nil

VELOCITY INFORMATION

t Δt analysis

HORIZONTAL SCALE



TRAVERSE GL3

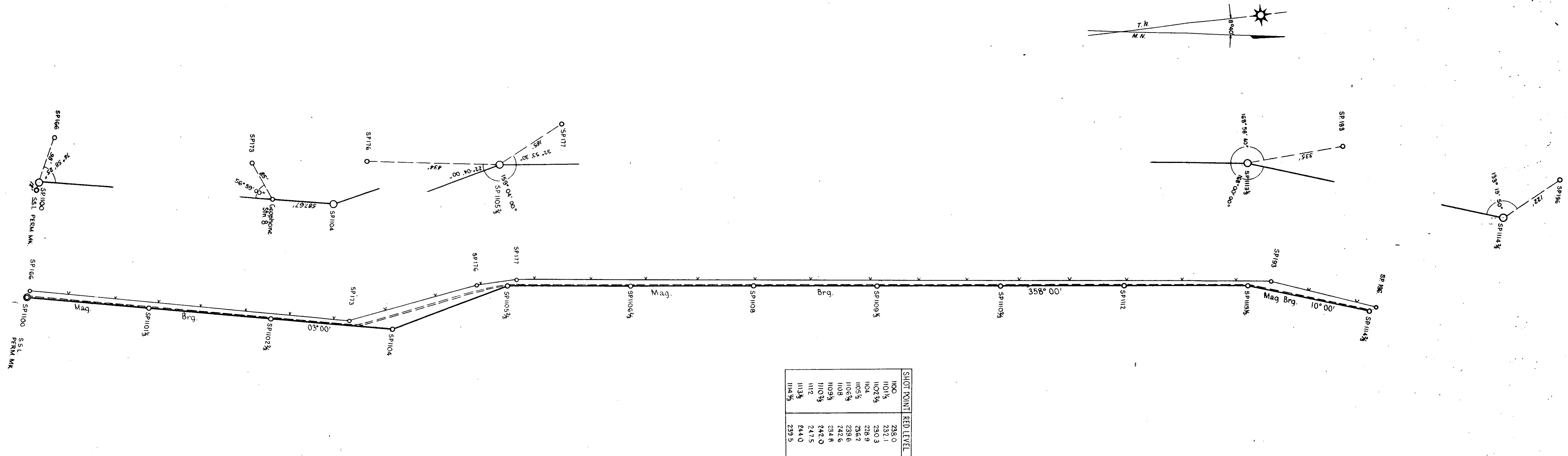
SP896 1/4 - SP900

RECORDED BY: Seismic Party No 2

SECTION BY: Bureau of Mineral Resources

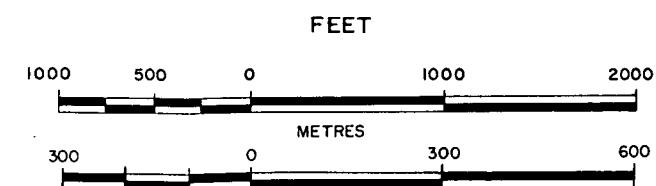
Playback Centre SIE MS 42 J54/B3-18A

Record No 1974/157



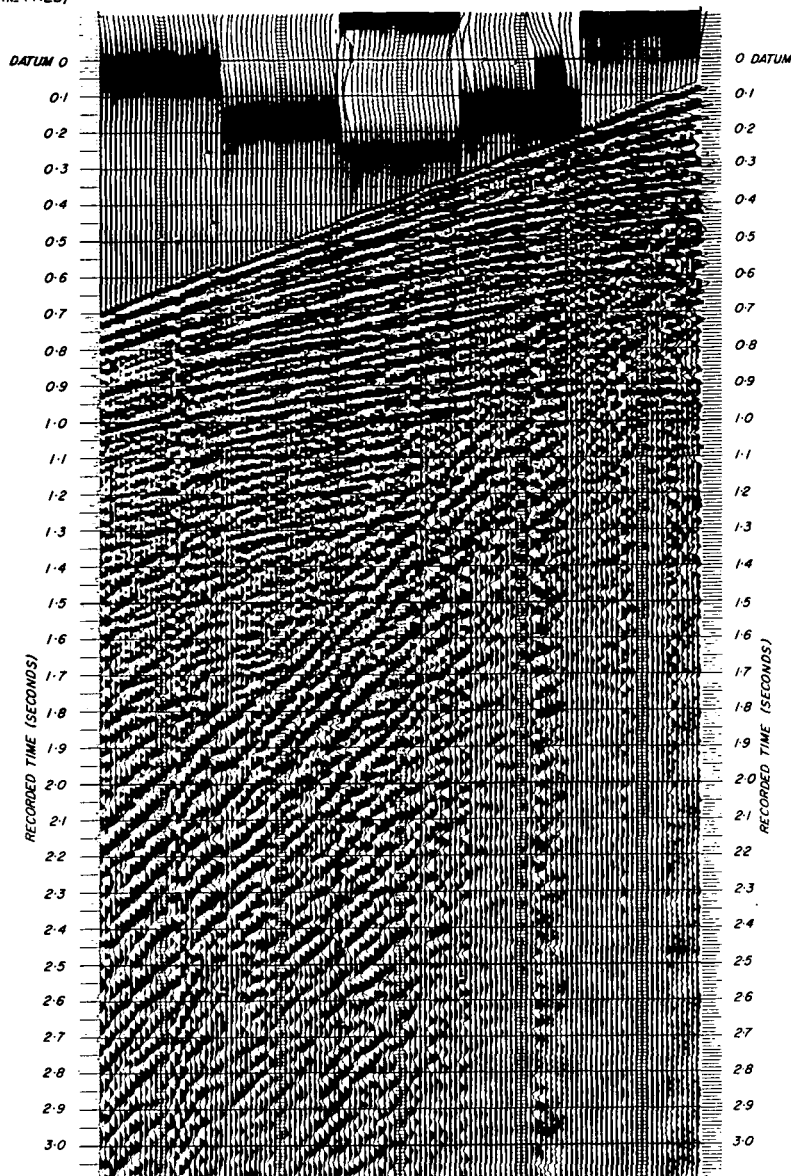
NOTE: Location map based on Department of the Interior Survey map. Measurements were made in feet during survey

SHOT-POINT LOCATION TRAVERSE SD2



DISTANCE 1179.6m
(METRES)

91.4m DISTANCE
(METRES)



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000B

Filters : K0-K120

A.G.C. : Off

Gain Initial : } Various
Final : }

Geophones : HSJ-14 Hz

Geophone pattern :

8/trace, bunched

Shot-hole pattern :

PLAYBACK INFORMATION

Filters : 0-1/135

A.G.C. : Off

Gain Initial : -40

Final : -40

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Longitudinal spreads-9.1m between traces

TRAVERSE SD2

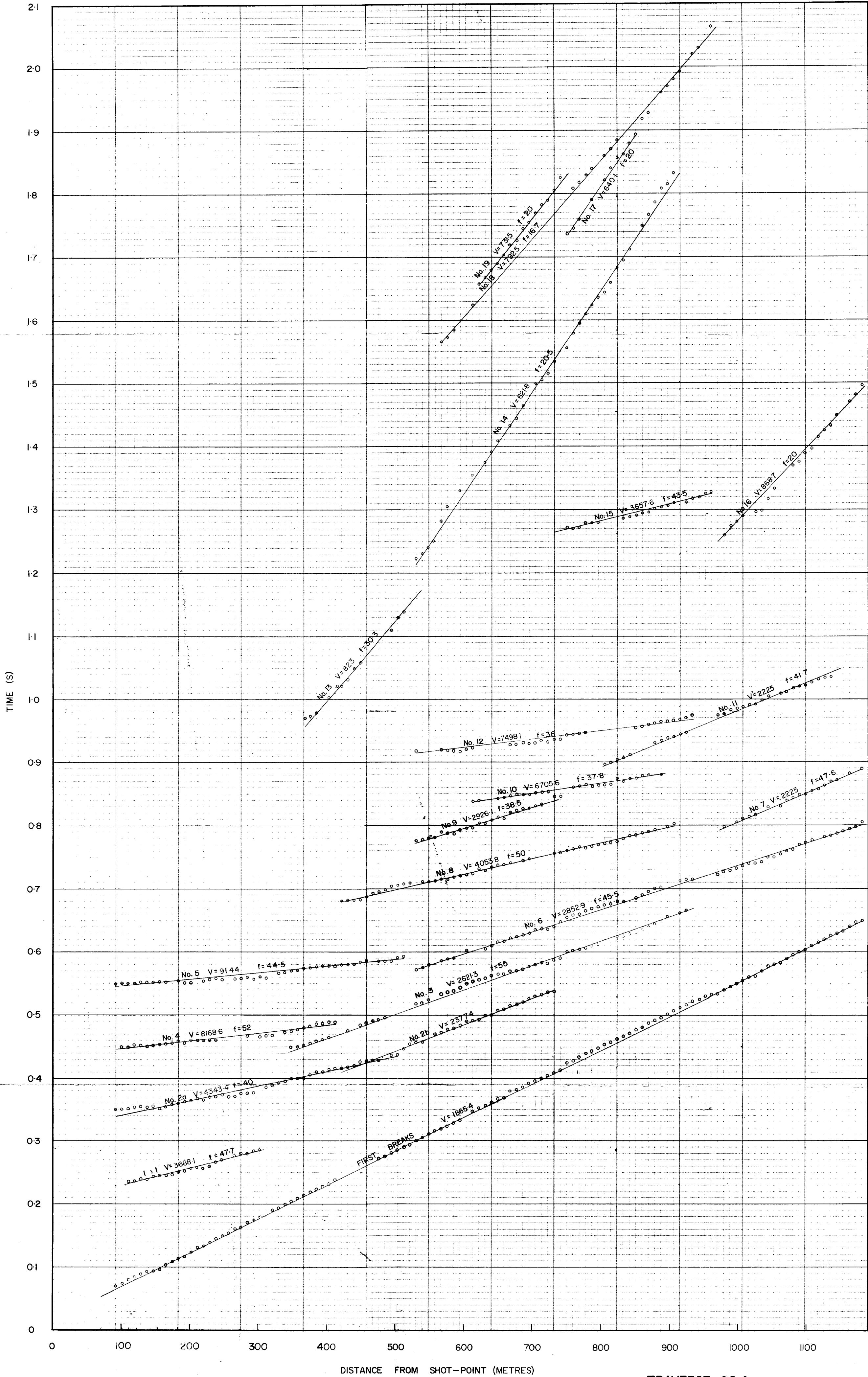
NOISE ANALYSIS SPI100

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources
Playback Centre SIE MS 42

J54/B3-17A

Record No 1974/157

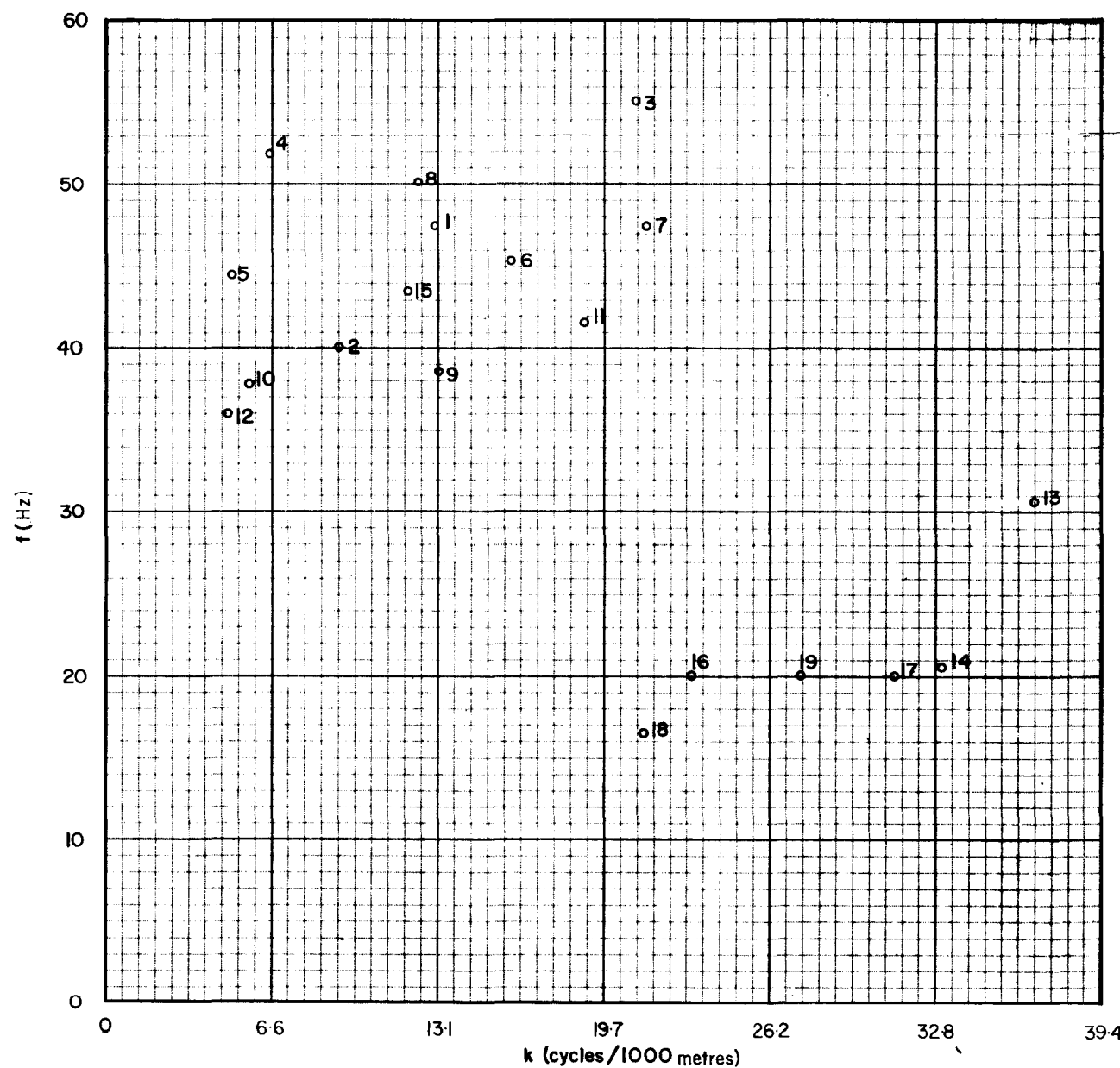
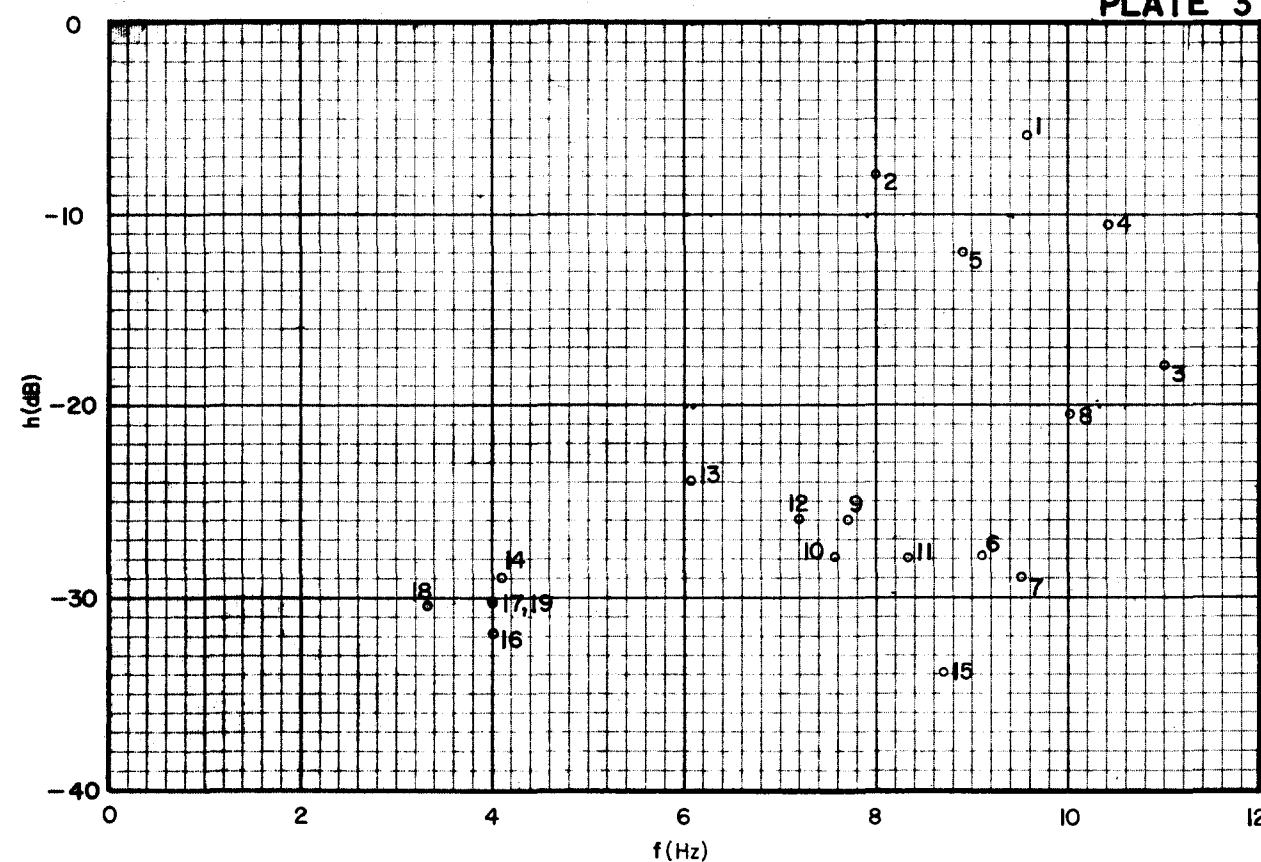
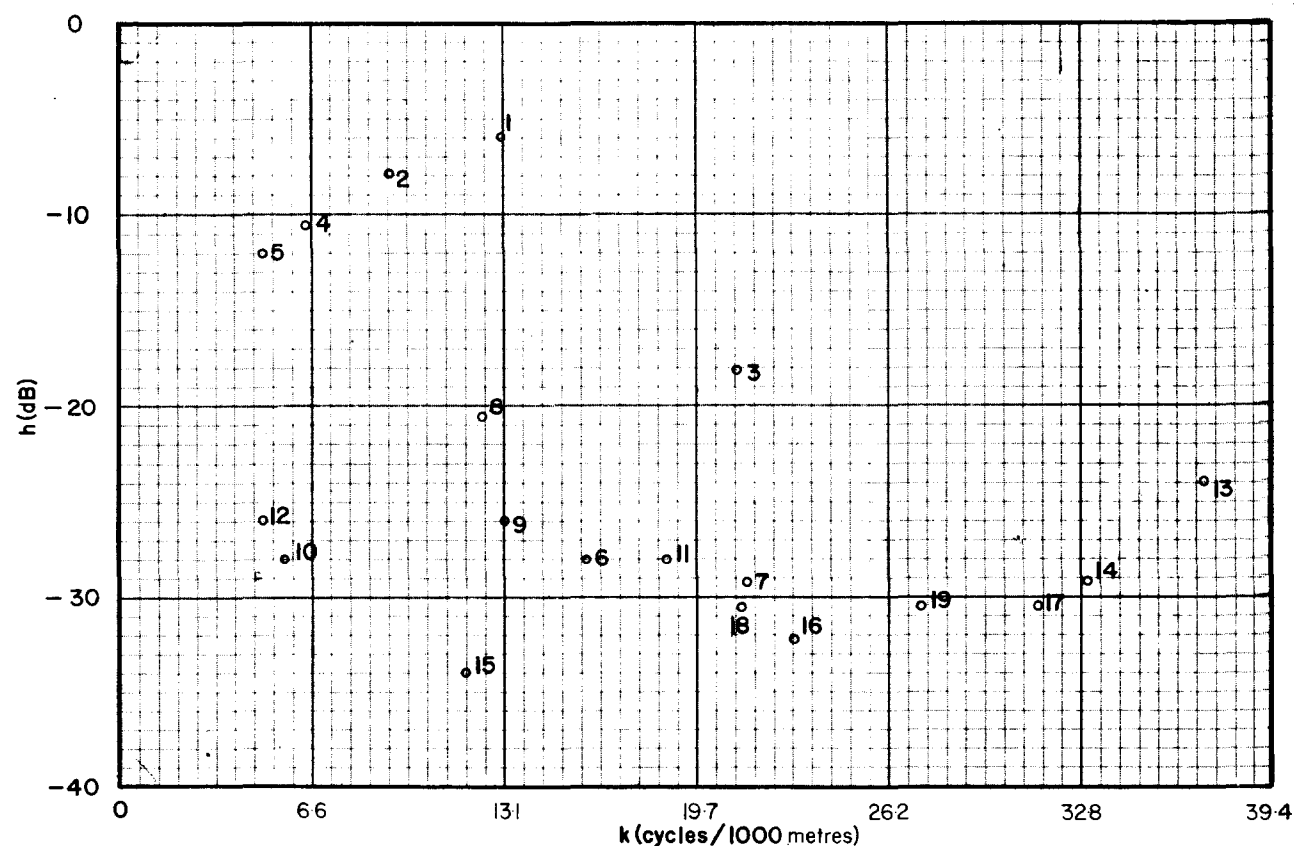


V=Velocity (m/s)
f=Estimated Peak Frequency (Hz)

DISTANCE FROM SHOT-POINT (METRES)

TRAVERSE SD 2

NOISE ANALYSIS SP 1100

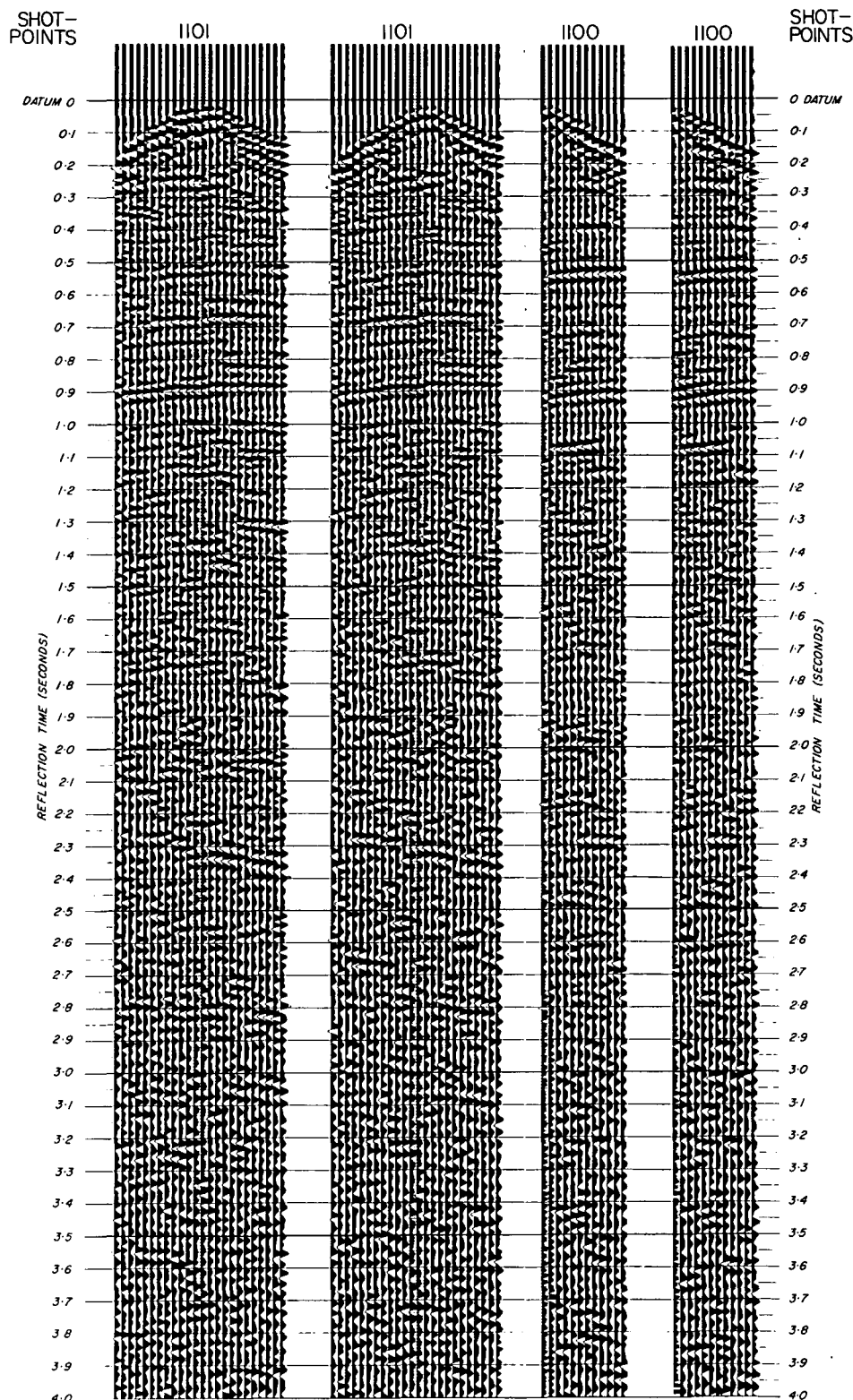


h = Relative Amplitude

k = Wave number

f = Frequency

TRAVERSE S.D. 2
NOISE ANALYSIS SP 1100



SHOT-HOLE PATTERN

7 HOLES, 15.2 m APART IN LINE DEPTH 12.2/13.7m CHARGE 7X6.8kg	5 HOLES, 15.2 m APART IN LINE DEPTH 12.2/13.7m CHARGE 5X9.1kg	5 HOLES, 15.2m APART IN LINE-- DEPTH 12.2/13.7m CHARGE 5X9.1kg	3 HOLES, 15.2m APART IN LINE DEPTH 12.2/13.7m CHARGE 3X13.6kg
---	---	--	---

CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000B

Filters : Prefilters 18Hz, 12 dB/o
K0-K92

A.G.C. : Med

Gain Initial : -60

Final : -30

Geophones : HSJ-14 Hz

Geophone pattern :
16/trace, 4.6m apart in line
Station interval 33.5m

Shot-hole pattern :
As indicated

PLAYBACK INFORMATION

Filters : 1/20-2/60

A.G.C. : Med

Gain Initial : -50

Final : -30

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

$t:\Delta t$

HORIZONTAL SCALE
Spread length 402.3m

TRAVERSE SD 2

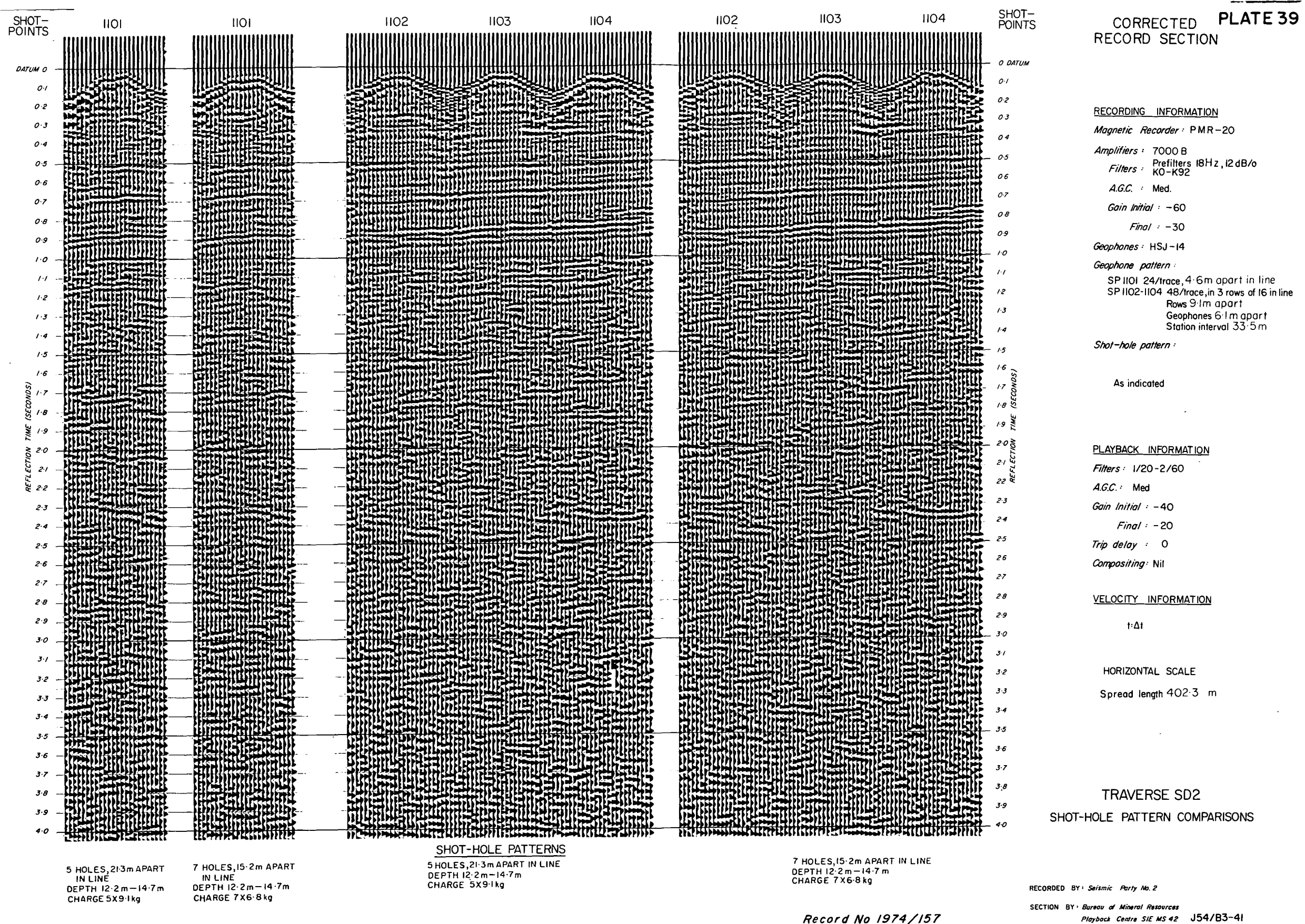
SPI100 & 1101

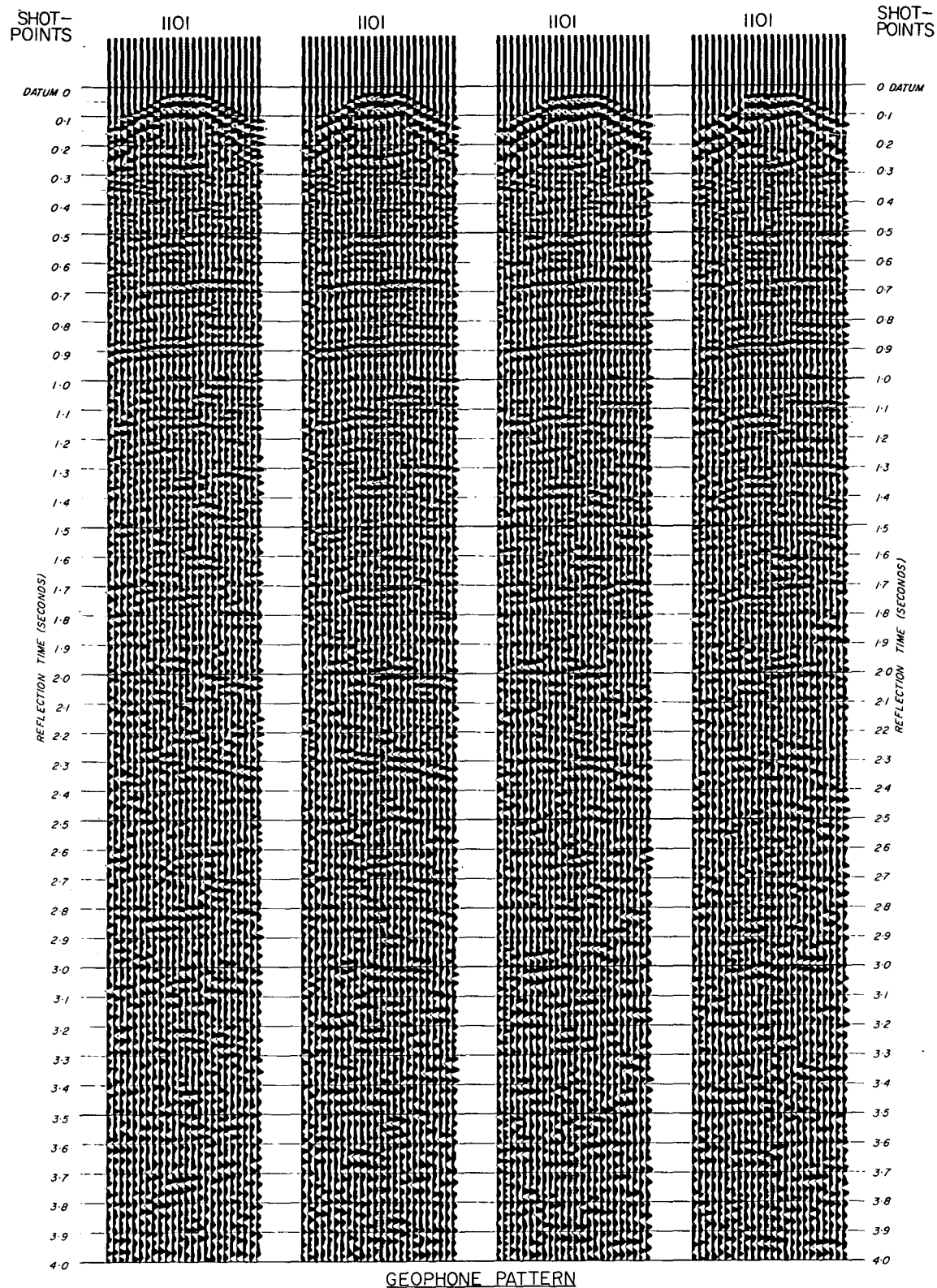
SHOT-HOLE PATTERN COMPARISONS

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources
Playback Centre SIE MS 42 J54/B3-31A

Record No 1974/157





CORRECTED RECORD SECTION PLATE 40

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000 B
Filters: Prefilters 18 Hz, 12 dB/o
K0-K92
A.G.C.: Med.

Gain Initial: -60

Final: -30

Geophones: HSJ-14 Hz

Geophone pattern:

As indicated
Station interval 335 m

Shot-hole pattern:

7 holes, 15.2 m apart in line
Depth 12.2-13.7 m
Charge 7x6.8 kg

PLAYBACK INFORMATION

Filters: 1/20-2/60

A.G.C.: Med.

Gain Initial: -50

Final: -30

Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

$t/\Delta t$

HORIZONTAL SCALE

Spread length 402.3 m

TRAVERSE SD 2

SPII01

GEOPHONE PATTERN COMPARISONS

16/trace 6.1 m apart in
line

48/trace in 3 rows of
16 in line
Rows 9.1 m apart
Geophones 6.1 m apart

24/trace, 4.6 m apart
in line

48/trace in 2 rows of
24 in line
Rows 9.1 m apart
Geophones 4.6 m apart

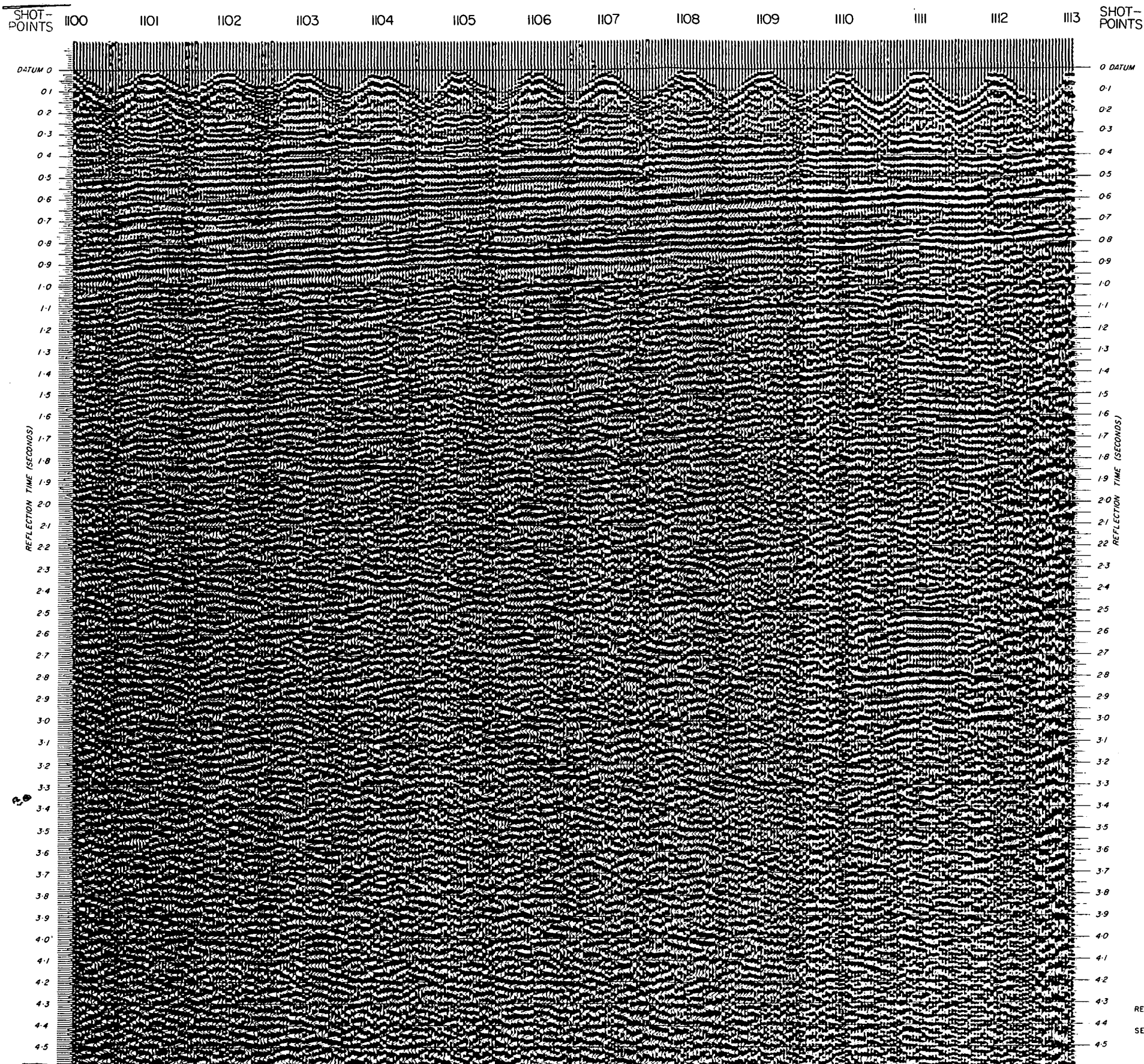
RECORDED BY: Seismic Party No. 2

SECTION BY: Bureau of Mineral Resources
Playback Centre SIE MS 42

J54/B3-39

Record No. 1974/157

CORRECTED
RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder: PMR 20

Amplifiers: 7000B

Filters: PREFILTERS 18Hz, 12dB/O

A.G.C.: Med.

Gain Initial: -60

Final: -30

Geophones: HSJ-14 Hz

Geophone pattern:

48/traces in 3 rows of 16 in line

Rows 9.1m apart

Geophones 6.1m apart

Station interval 33.5m

Shot-hole pattern:

5 holes, 21.3m apart in line

Depth 12.2/14.6m

Charge 5x 9.1kg

PLAYBACK INFORMATION

Filters: 1/20 - 2/60

A.G.C.: Med.

Gain Initial: -40

Final: -20

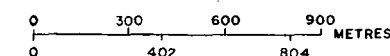
Trip delay: 15 s

Compositing: Nil

VELOCITY INFORMATION

tΔt analysis

HORIZONTAL SCALE



TRAVERSE SD2

SPII00 - SPII13

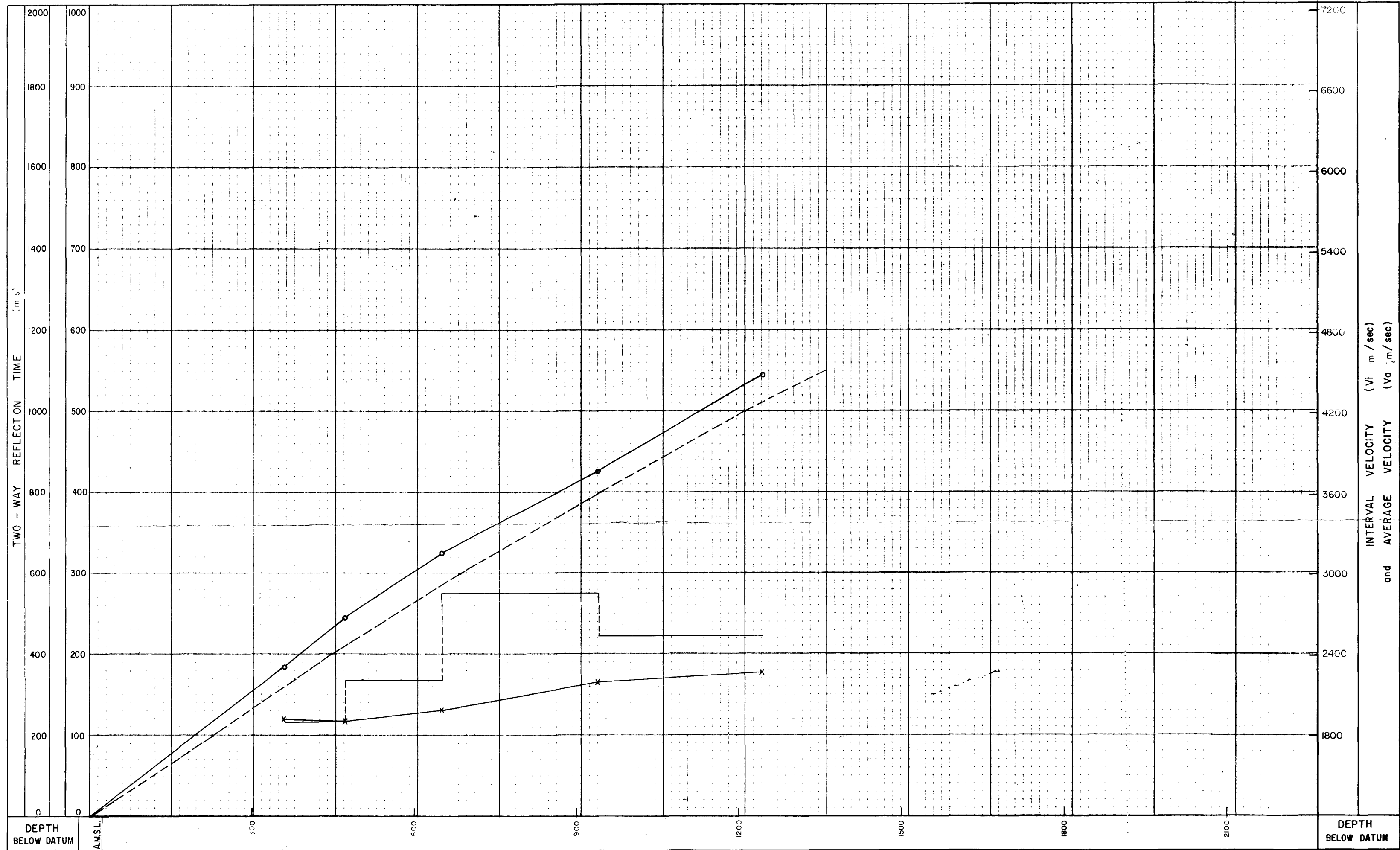
RECORDED BY: Seismic Party No. 2

SECTION BY: Bureau of Mineral Resources

Playback Centre SIE MS 42

J54/B3-16

Record No 1974/157



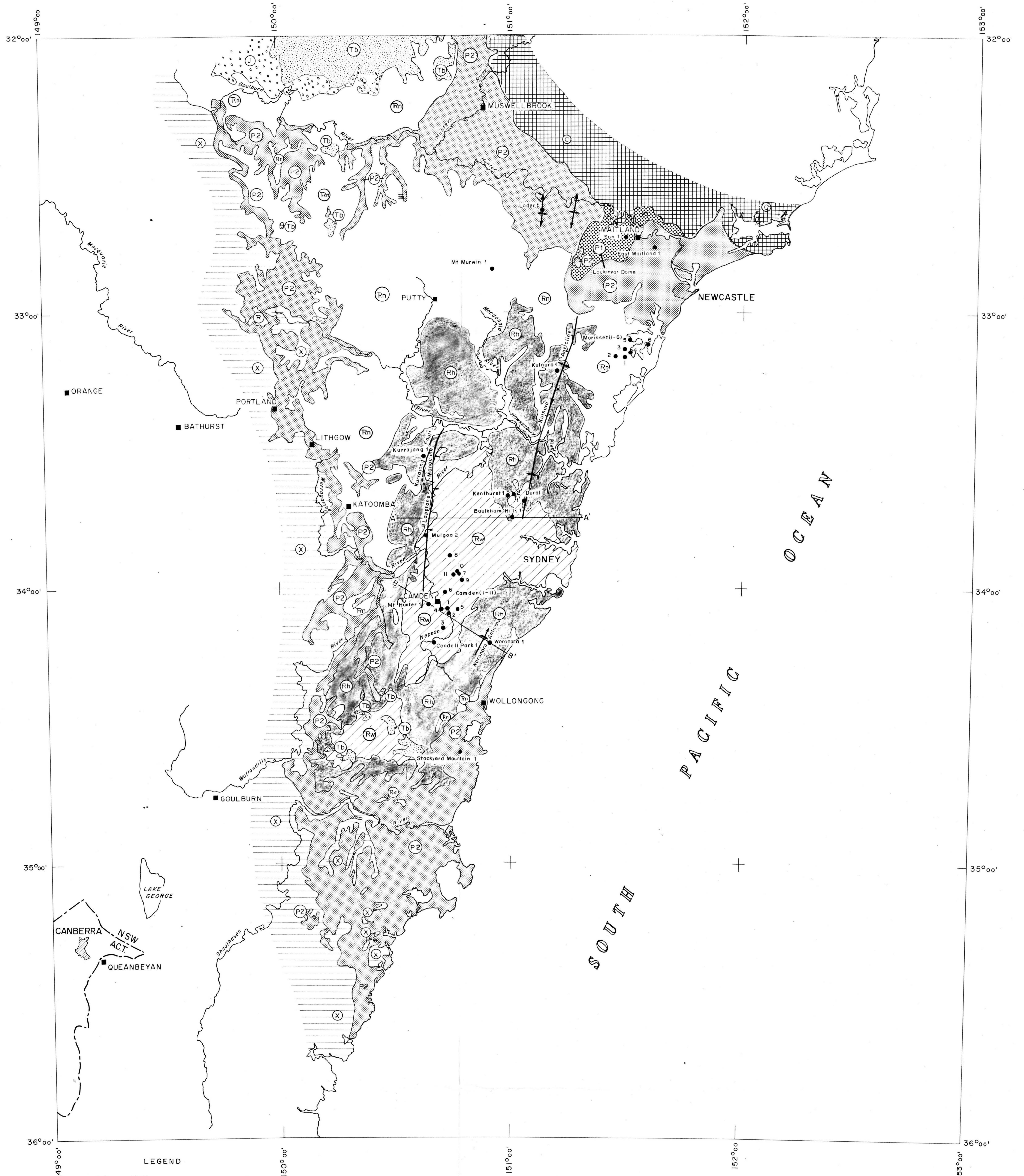
VELOCITY AND TIME VERSUS DEPTH

AREA TRAVERSE SD 2

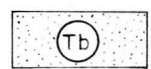
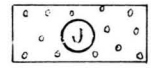
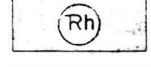
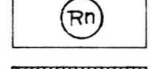
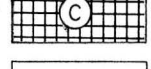
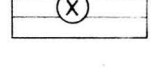
Basis t:Δt

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

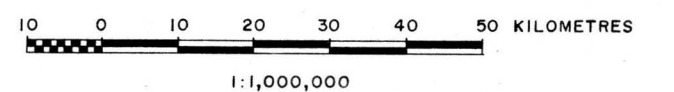
J54/B3-7

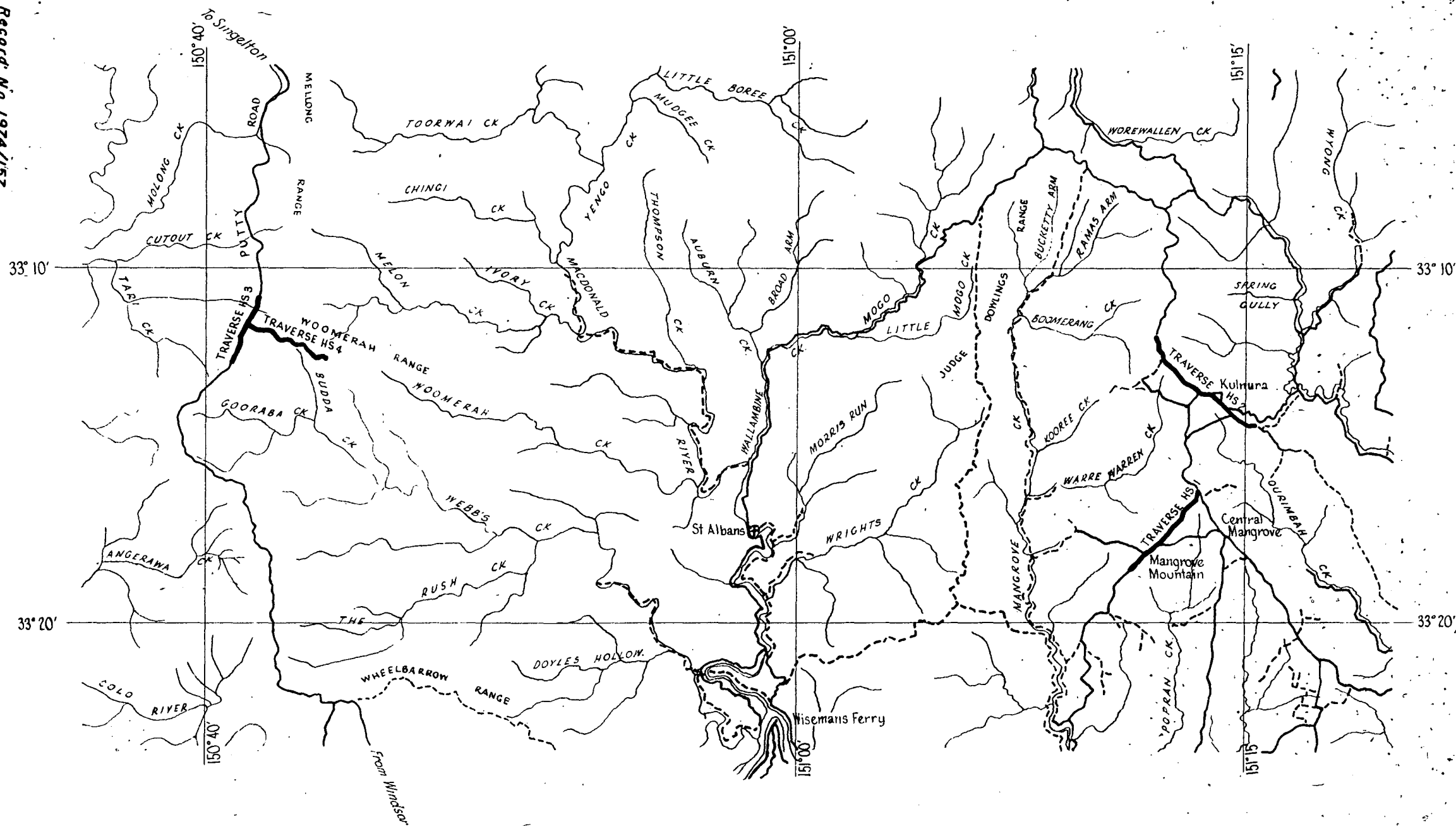


LEGEND

- 9 Well
-  Tertiary Volcanics
-  Jurassic
-  Triassic
 -  Wianamatta Group
 -  Hawkesbury Sandstone
 -  Narrabeen Group
-  Permian
 -  Former "Upper Marine Series" and "Upper Coal Measures"
 -  Former "Lower Marine Series" and "Lower Coal Measures"
-  Carboniferous
-  Pre-Carboniferous sediments and metamorphics
Igneous rocks

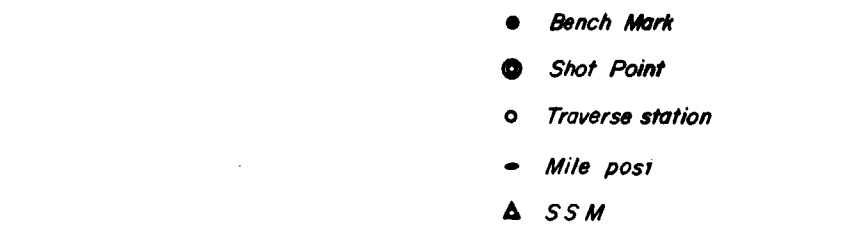
SYDNEY BASIN
REGIONAL GEOLOGY





SYDNEY BASIN
LOCALITY MAP





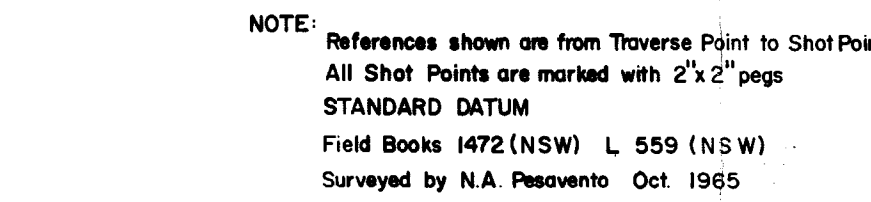
NOTE: Traverse H53 references shown, are from traverse to SP
2'x2' pegs placed at all SPs

Traverse H54 references shown are from SPs to star picks found
2'x2' pegs placed at all SPs, except SPs 1704 & 1706's, where gov. iron nails have been set in rock.

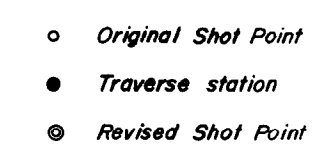
STANDARD DATUM

Field Books F 1473 (NSW) L 561 (NSW)

Surveyed by N.A. Pesovento Nov. 1965

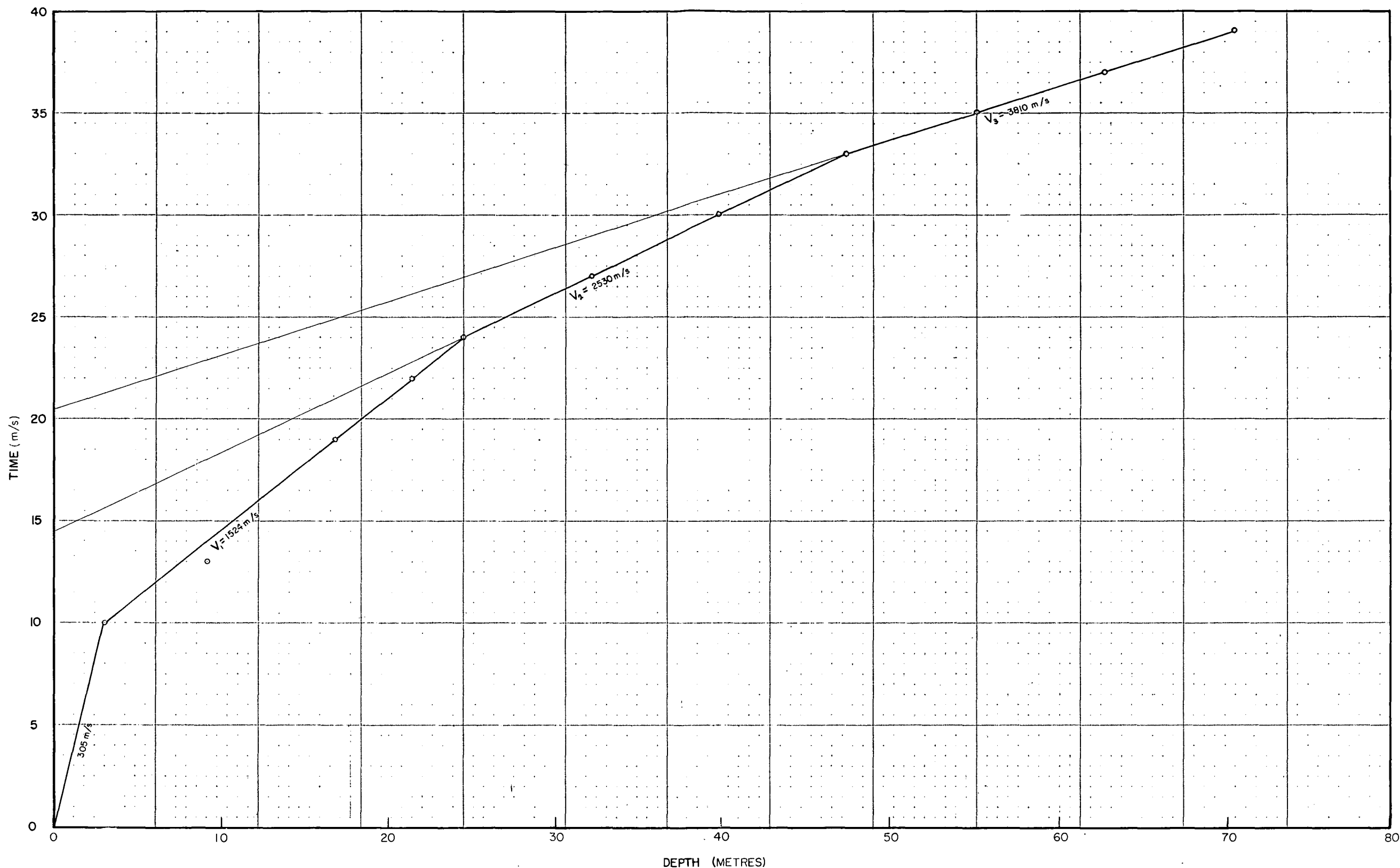


NOTE: References shown are from Traverse Point to Shot Point
All Shot Points are marked with 2"x2" pegs
STANDARD DATUM
Field Books 1472 (NSW) L 559 (NSW)
Surveyed by N.A. Pasavento Oct. 1965



NOTE: References are from Traverse Points to Shot Points
All Shot Points marked with 2" x 2" pegs
STANDARD DATUM
Field Books F 1474 (NSW) L 560 (NSW)
Surveyed by N.A. Pesavento Oct. 1965
Location map based on Department of the
Interior survey map Measurements made in
feet during survey

Graphic scale bars for feet and metres. The top bar is labeled 'FEET' and has markings at 1000, 500, 0, 1000, and 2000. The bottom bar is labeled 'METRES' and has markings at 300, 0, 300, and 600.



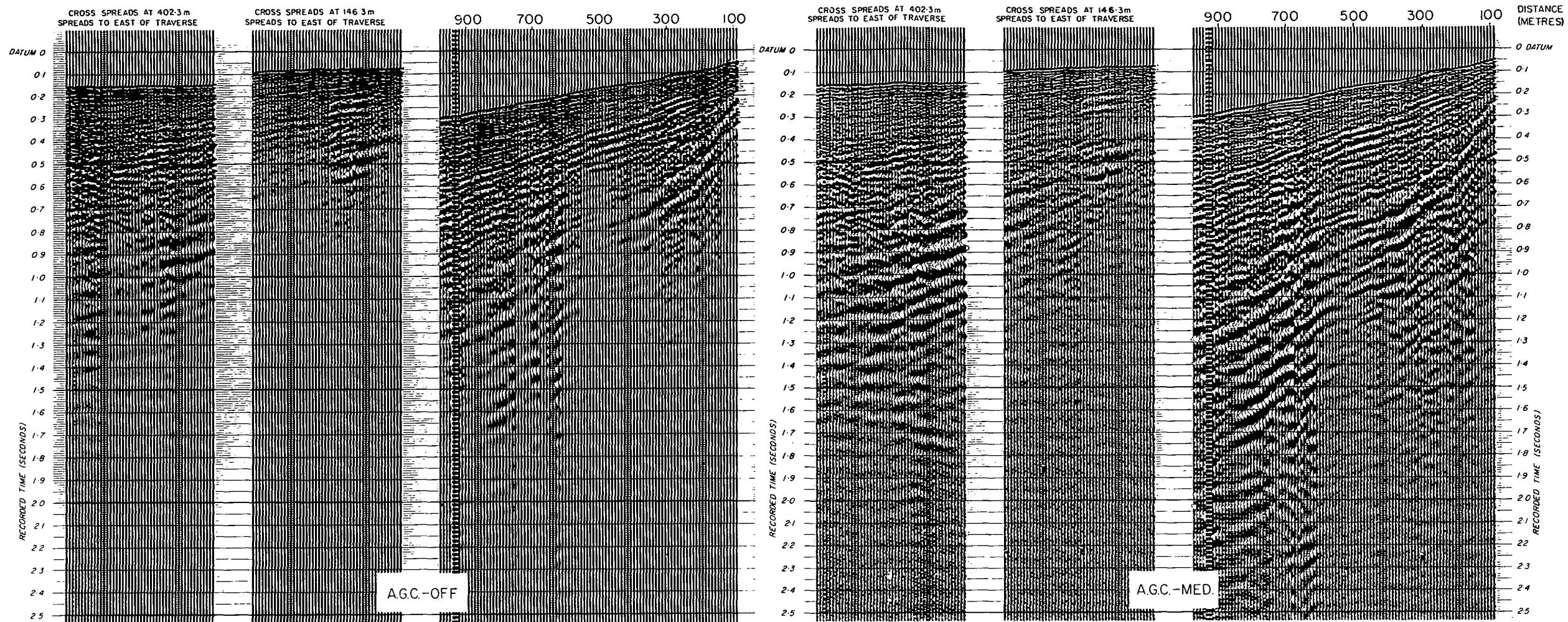
SOFT SANDSTONE			SOFT SANDSTONE			SANDSTONE			MEDIUM SANDSTONE		
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DRILL LOG

SANDY TOPSOIL
V. HARD IRONSTONE
SOFT SANDSTONE
V. HARD IRONSTONE
MEDIUM SANDSTONE
HARD SANDSTONE
V. HARD SANDSTONE
V. HARD SANDSTONE

HARD SANDSTONE
V. HARD SANDSTONE
MEDIUM SANDSTONE

TRAVERSE HS. I
UPHOLE SURVEY SP 1409A



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000B

Filters : K0-K120

A.G.C. : OFF

Gain Initial : } Various
Final : }

Geophones : EVS 8B-4.5Hz

Geophone pattern :
4/trace bunched

Shot-hole pattern :
—

PLAYBACK INFORMATION

Filters : 1/16 - 1/135

A.G.C. : Med. and Off

Gain Initial : with A.G.C. w/out A.G.C.

Final : -40 -40

Trip delay : 0-2s 0

Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Longitudinal spreads — 9.1 m between traces

Transverse spread --- 6.9 m between traces

TRAVERSE HSI

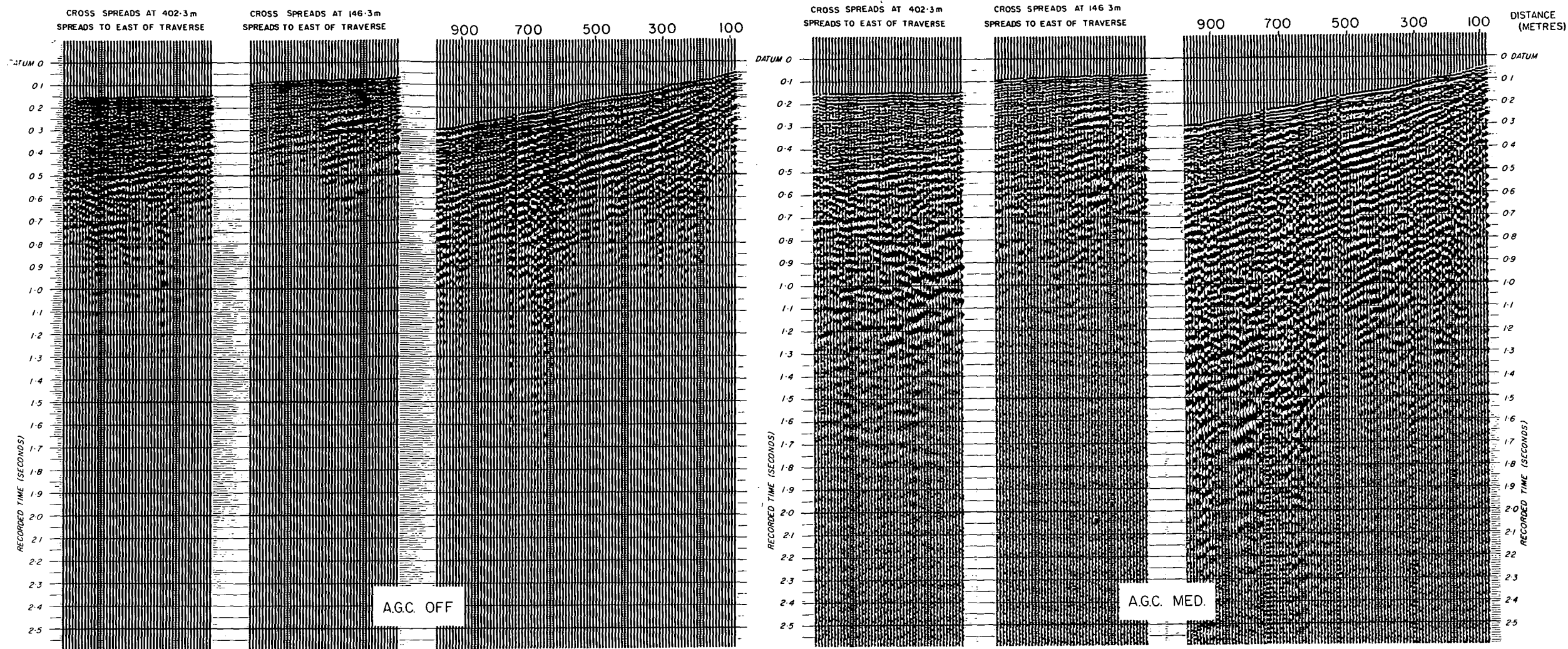
NOISE ANALYSIS SP1409B

Record No. 1974 /157

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources
Playback Centre SIE MS 42

156/B3-23



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20
 Amplifiers : 7000B
 Filters : PREFILTERS 18 Hz, 12 B/o
 A.G.C. : OFF KO-K120
 Gain Initial : } Various
 Final : }
 Geophones : HSJ-14 Hz
 Geophone pattern :
 8/trace bunched

Shot-hole pattern :

PLAYBACK INFORMATION

Filters : 1/16 - 1/135
 A.G.C. : Med. and Off
 Gain Initial : with A.G.C. w/out A.G.C.
 Final : -40 -40
 Trip delay : 0-2s 0
 Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Longitudinal spreads—9.1 m between traces
 Transverse spreads—6.9 m between traces

TRAVERSE HSI

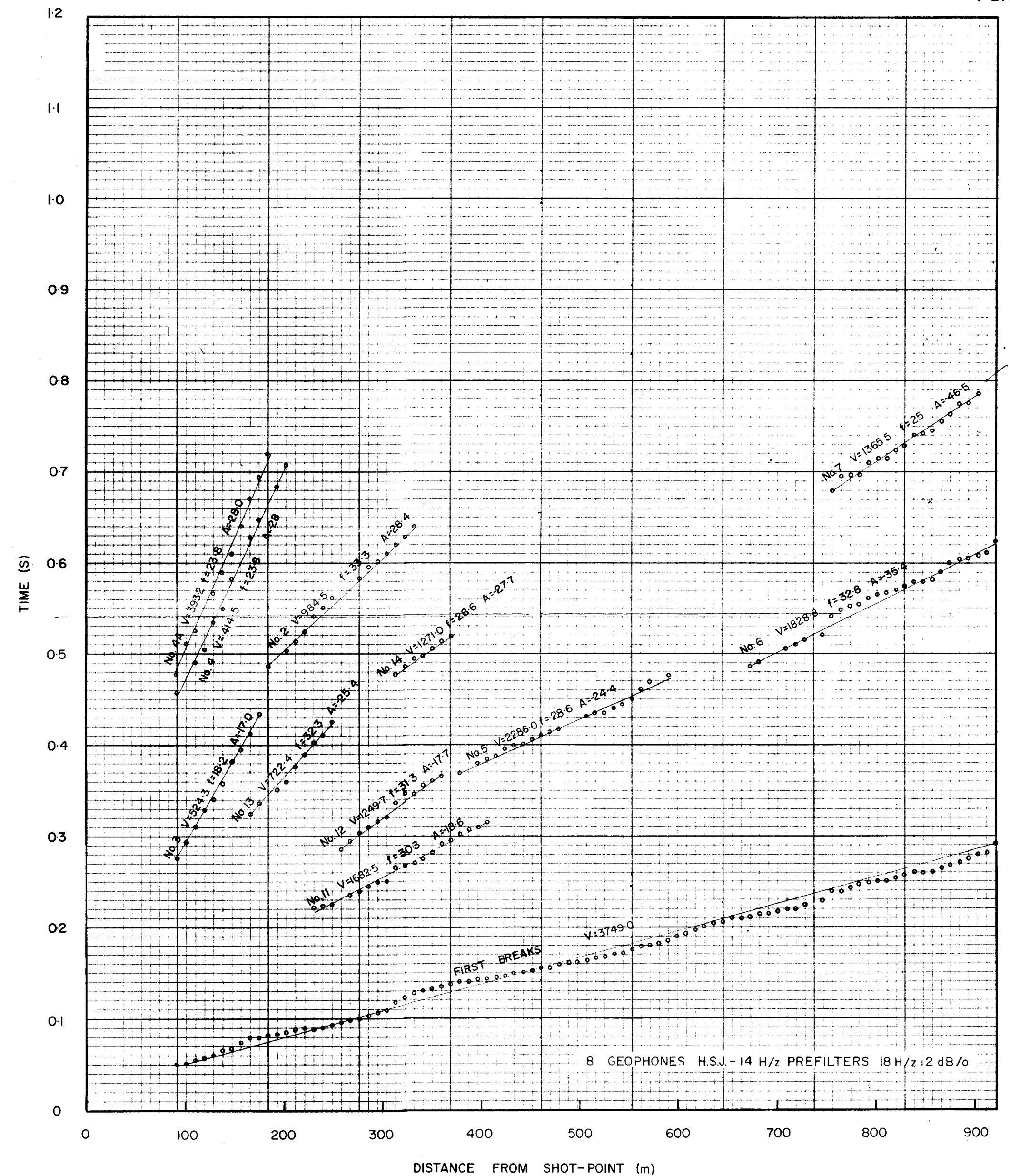
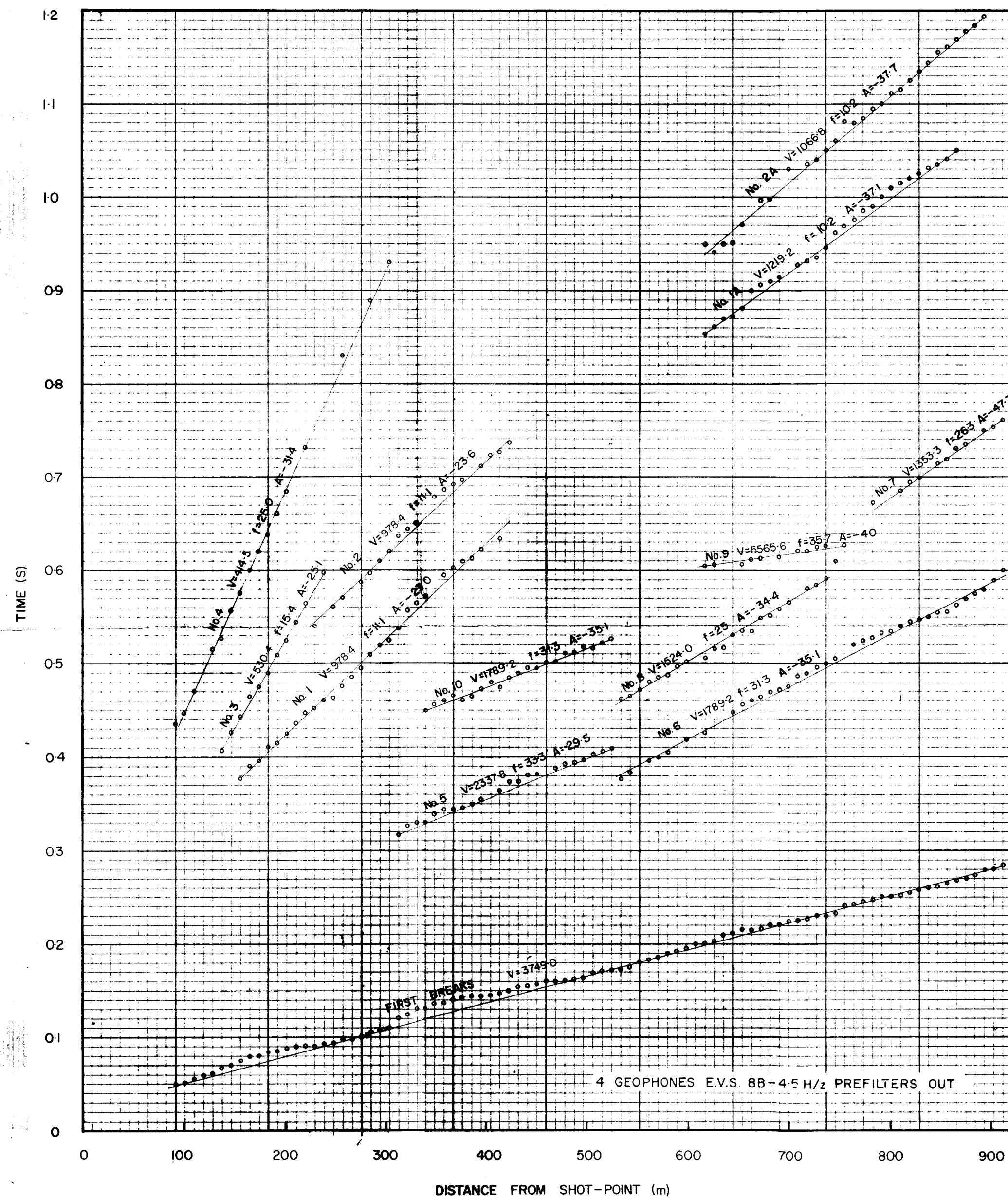
NOISE ANALYSIS SPI409 B

Record No. 1974/157

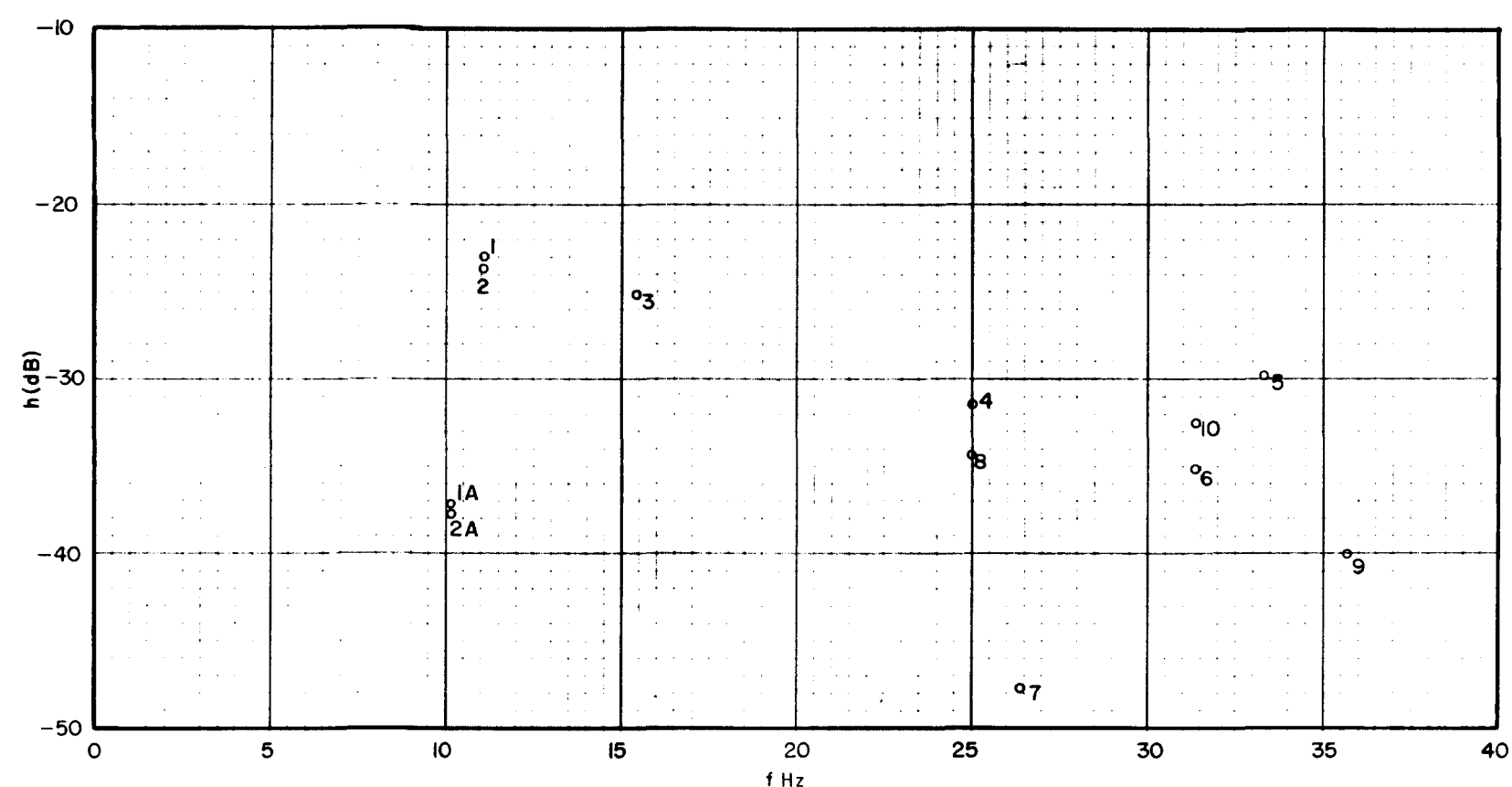
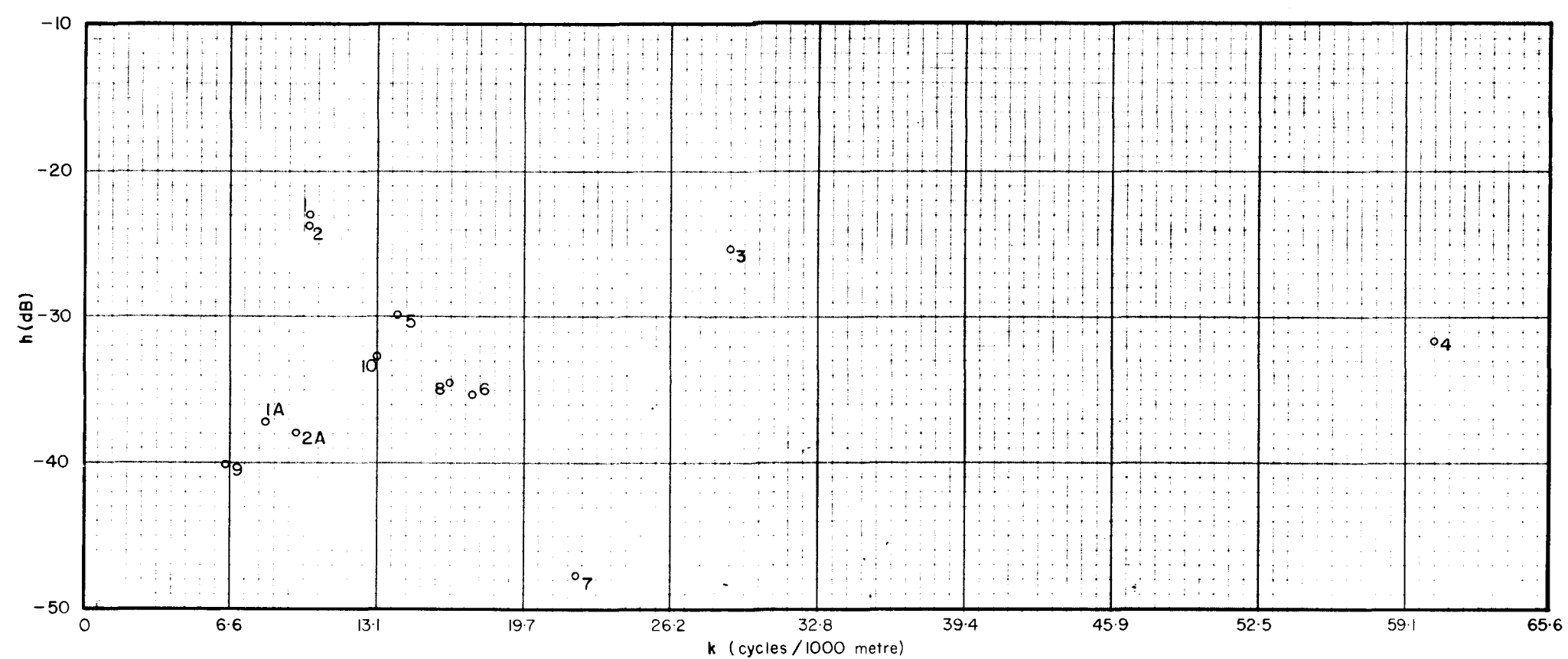
RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources
 Playback Centre SIE MS 42

156/B3-22

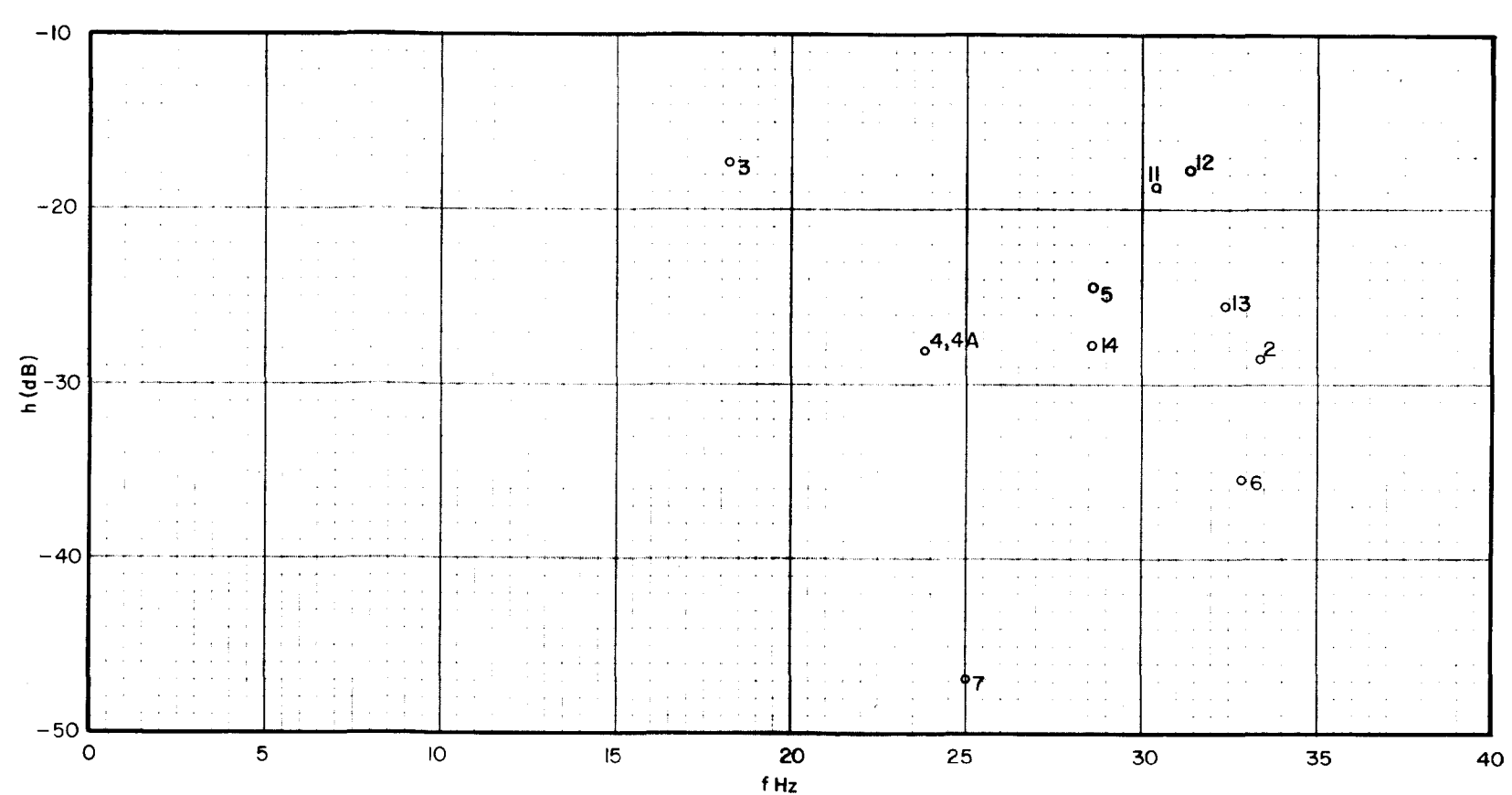
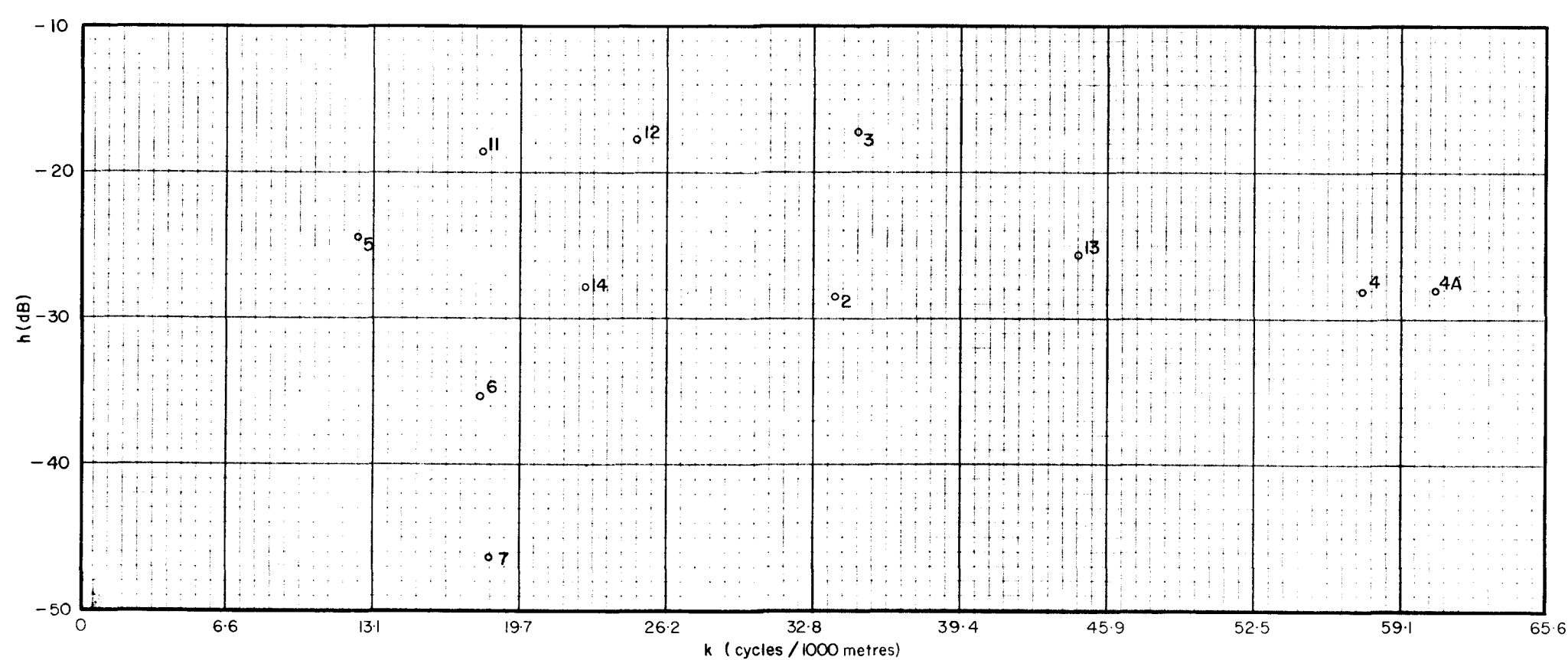
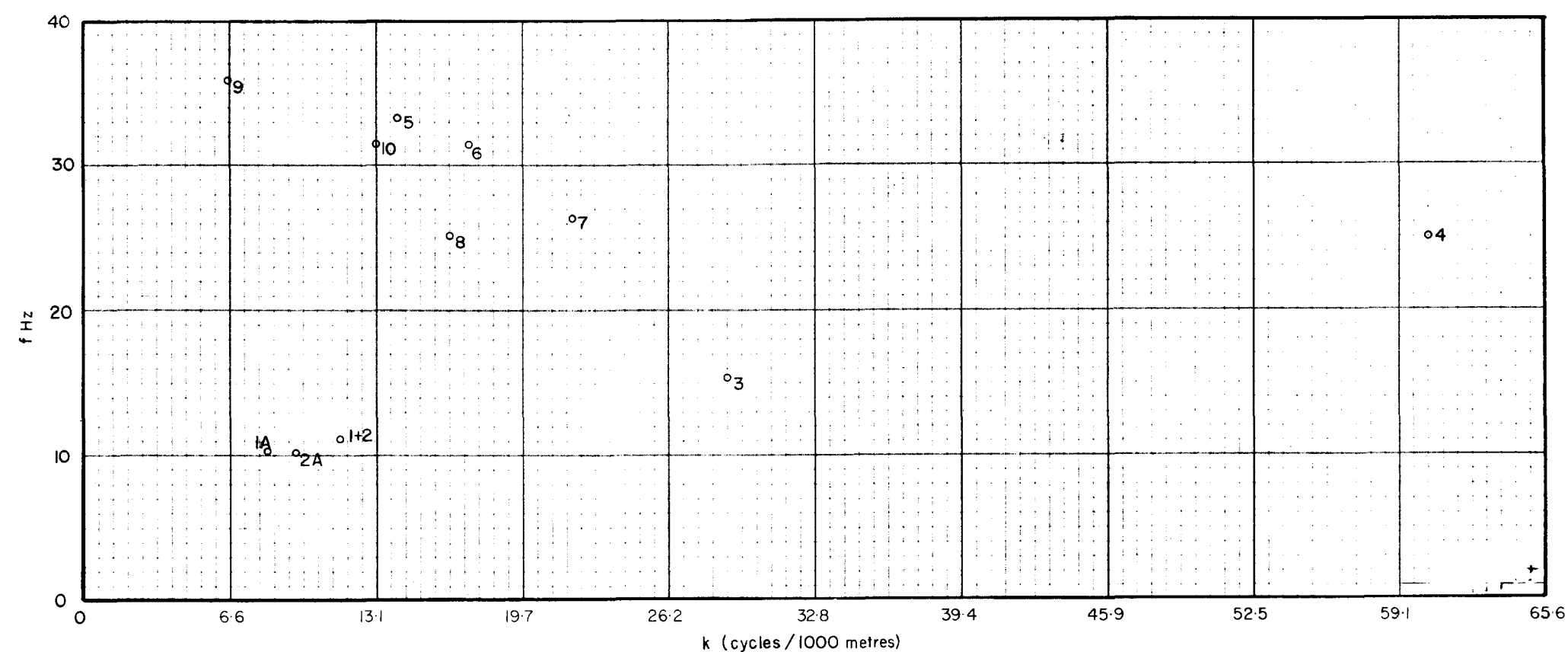


TRAVERSE HS I
NOISE ANALYSIS - SP 1409B



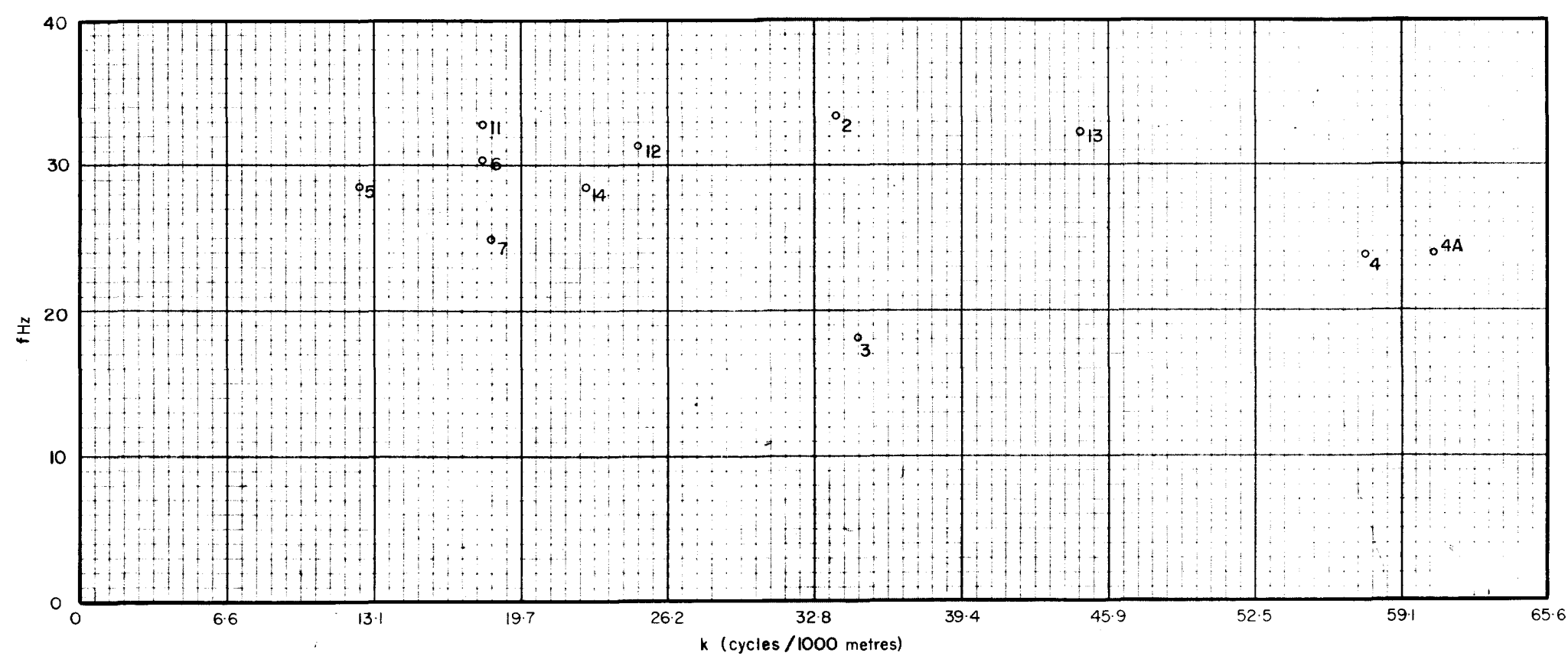
h = Relative Amplitude
k = Wave number
f = Frequency

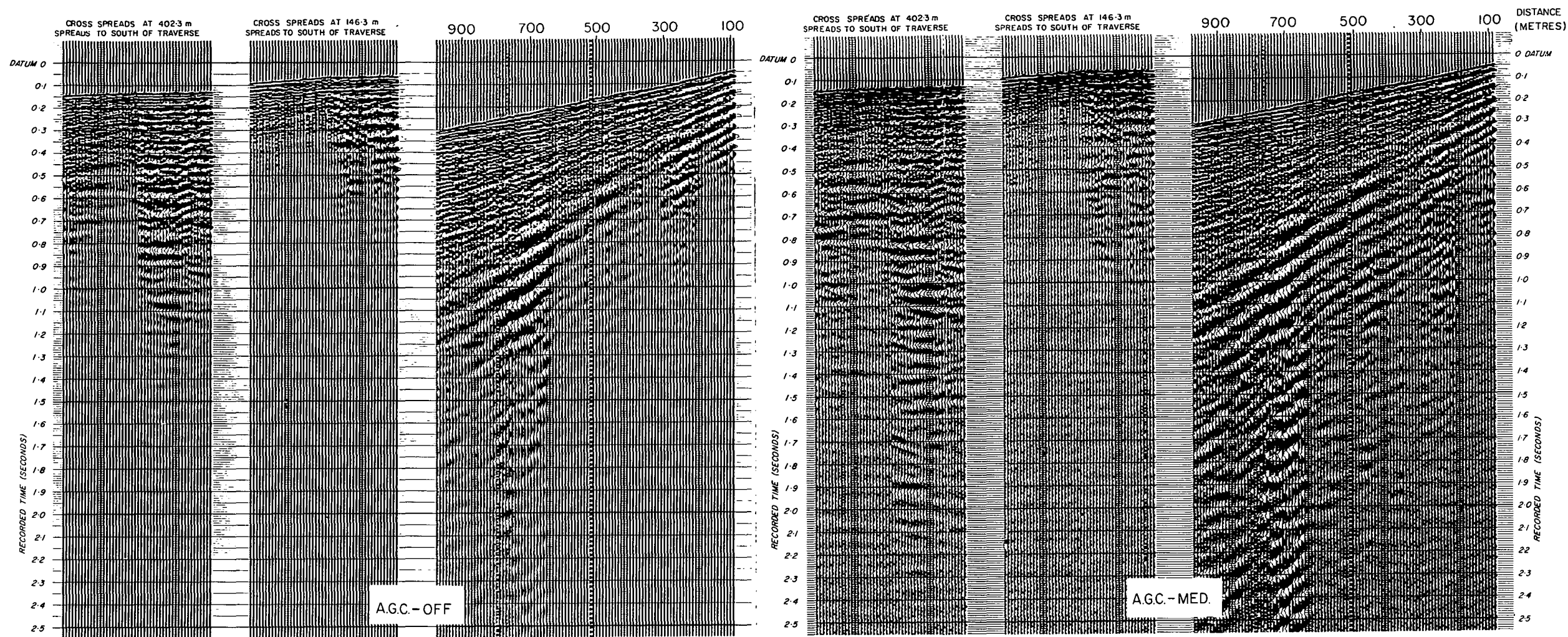
GEOPHONES EVS 8B-4.5 Hz
PREFILTERS OUT



h = Relative Amplitude
k = Wave number
f = Frequency

GEOPHONES HSJ - 14 Hz
PREFILTERS 18 Hz 12 dB/o





RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20
 Amplifiers : 7000B
 Filters : K0-K120
 A.G.C. : OFF
 Gain Initial : } Various
 Final : }
 Geophones : EVS 8B - 4.5 Hz
 Geophone pattern :
 4/trace bunched

Shot-hole pattern :
 —

PLAYBACK INFORMATION

Filters : 1/16 - 1/135
 A.G.C. : Med. and Off
 Gain Initial : with A.G.C. w/out A.G.C.
 Final : -40 -40
 Trip delay : 0-2s 0
 Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Longitudinal spread — 9.1m between traces
 Transverse spreads — 3.8m between traces

TRAVERSE HS 2

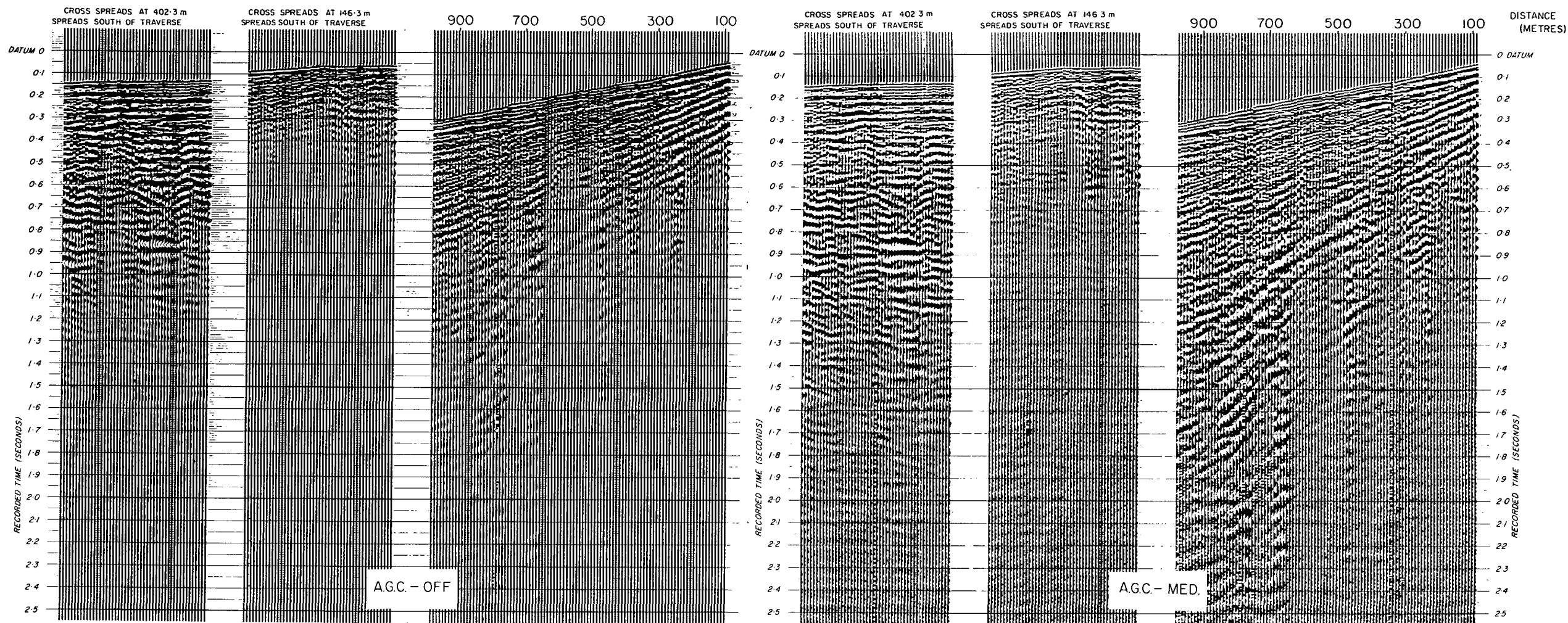
NOISE ANALYSIS SP 1487 B

Record No. 1974/157

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources
 Playback Centre SIE MS 42

156/B3-20



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20
 Amplifiers : 7000B
 Filters : PREFILTERS 18 Hz 12dB/o
 AGC : OFF KO-K92
 Gain Initial : } Various
 Final : }
 Geophones : HSJ-14 Hz
 Geophone pattern :
 8/trace bunched

Shot-hole pattern :
 —

PLAYBACK INFORMATION

Filters : 1/16 - 1/135
 AGC : Med. and Off
 Gain Initial : with AGC w/out AGC
 Final : -40 -40
 Trip delay : 0-2s 0
 Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE

Longitudinal spreads — 9.1 m between traces
 Transverse spreads — 3.9 m between traces

TRAVERSE HS 2

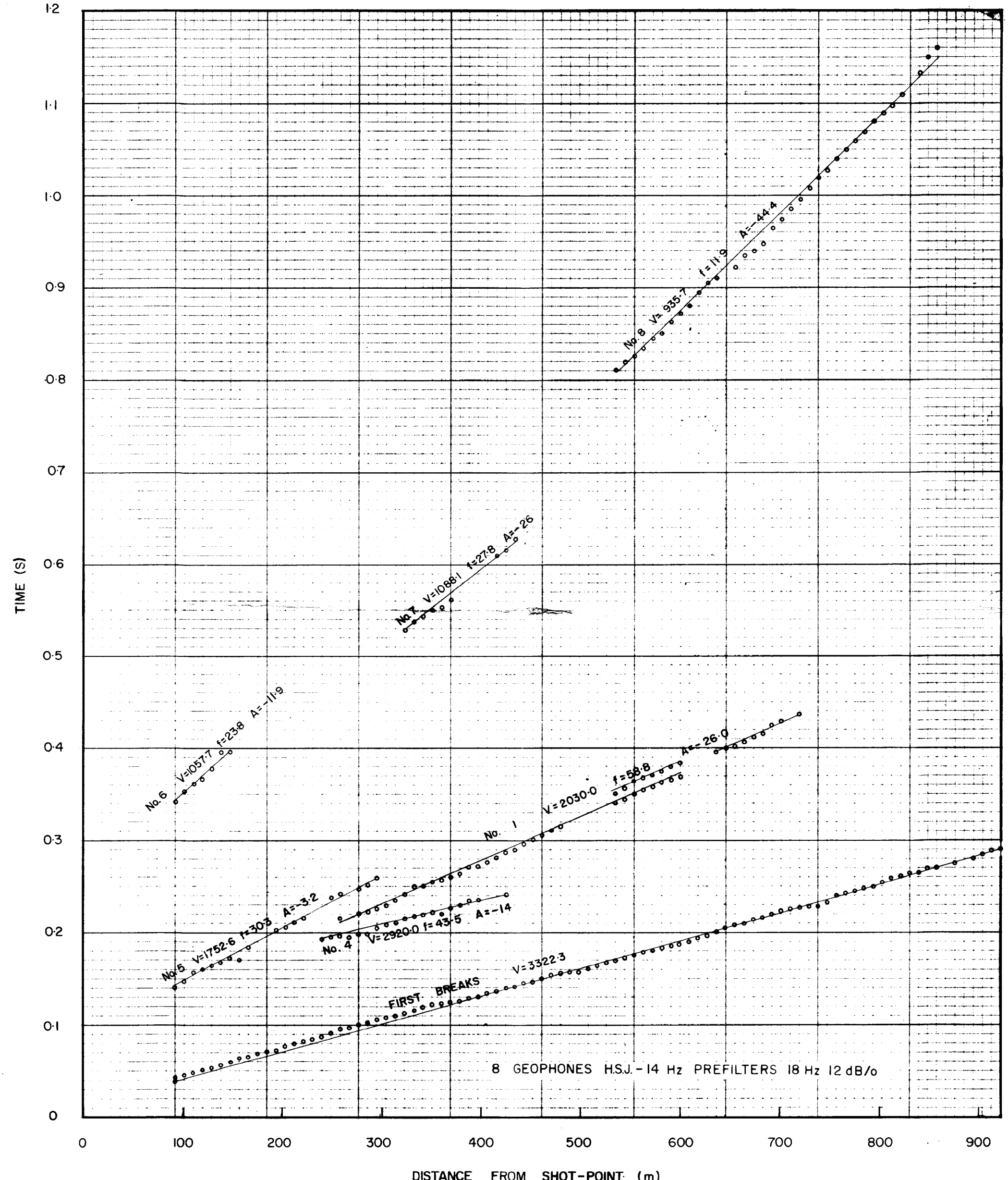
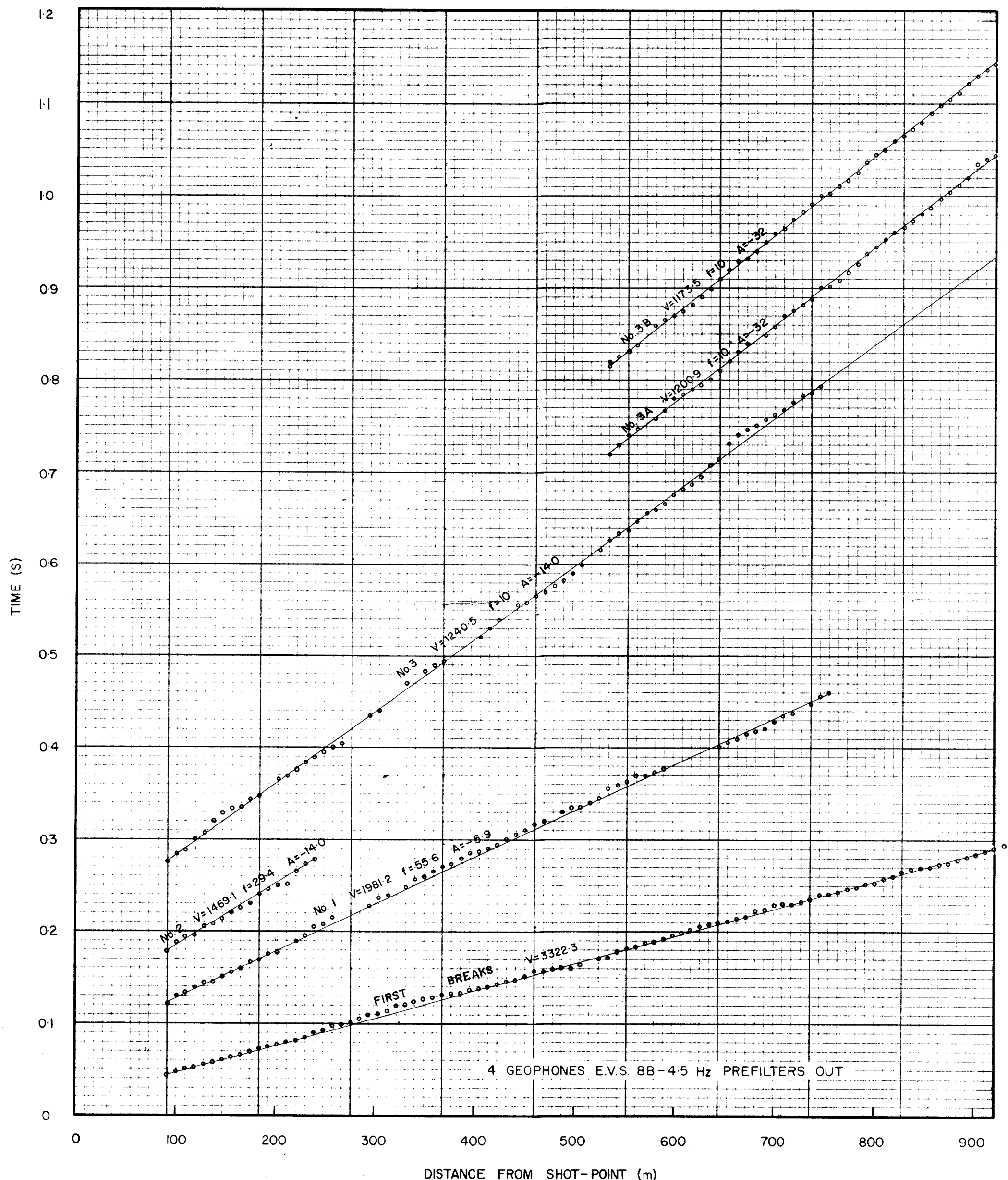
NOISE ANALYSIS SP 1487 B

Record No. 1974 / 157

RECORDED BY : Seismic Party No. 2

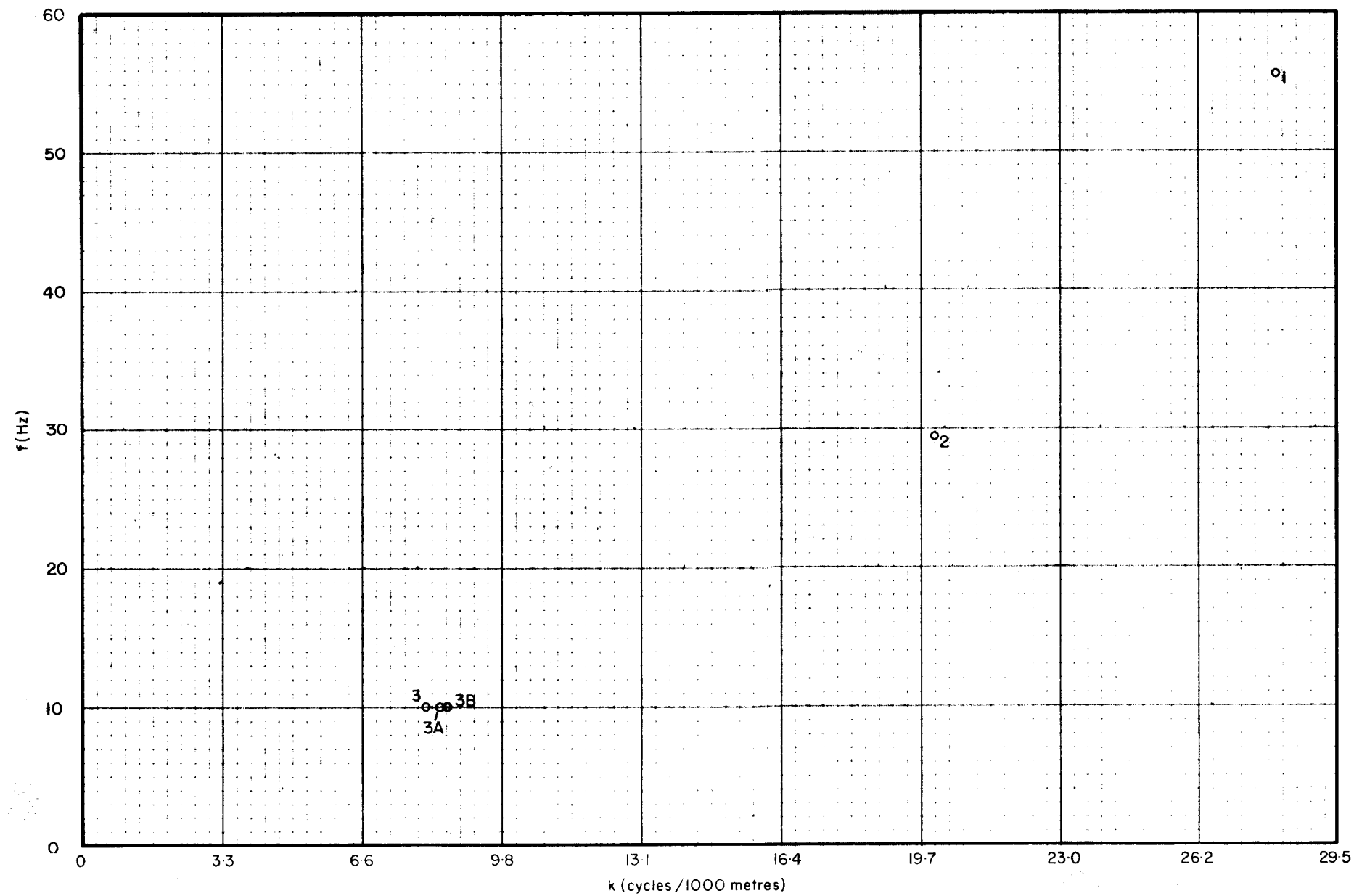
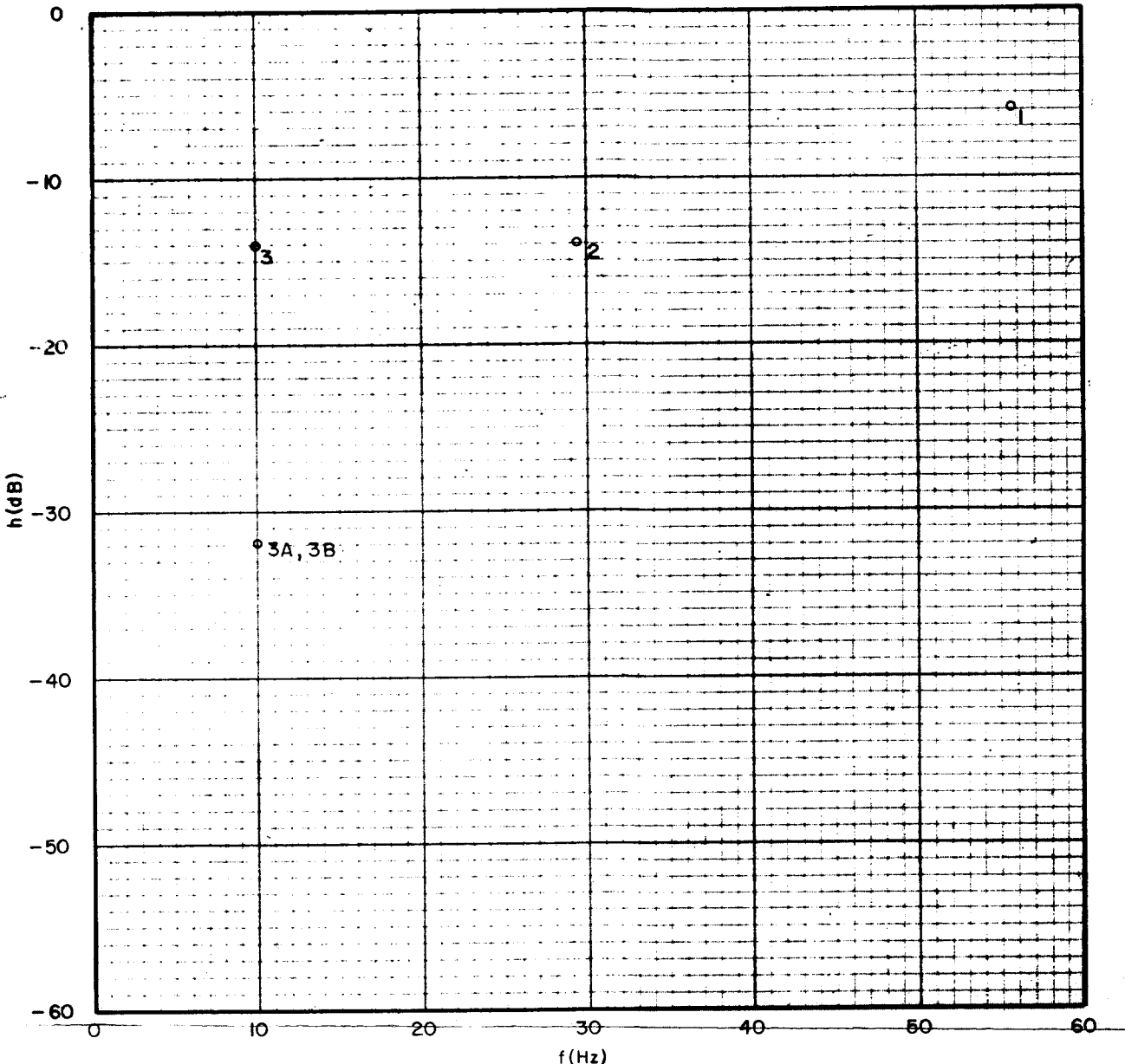
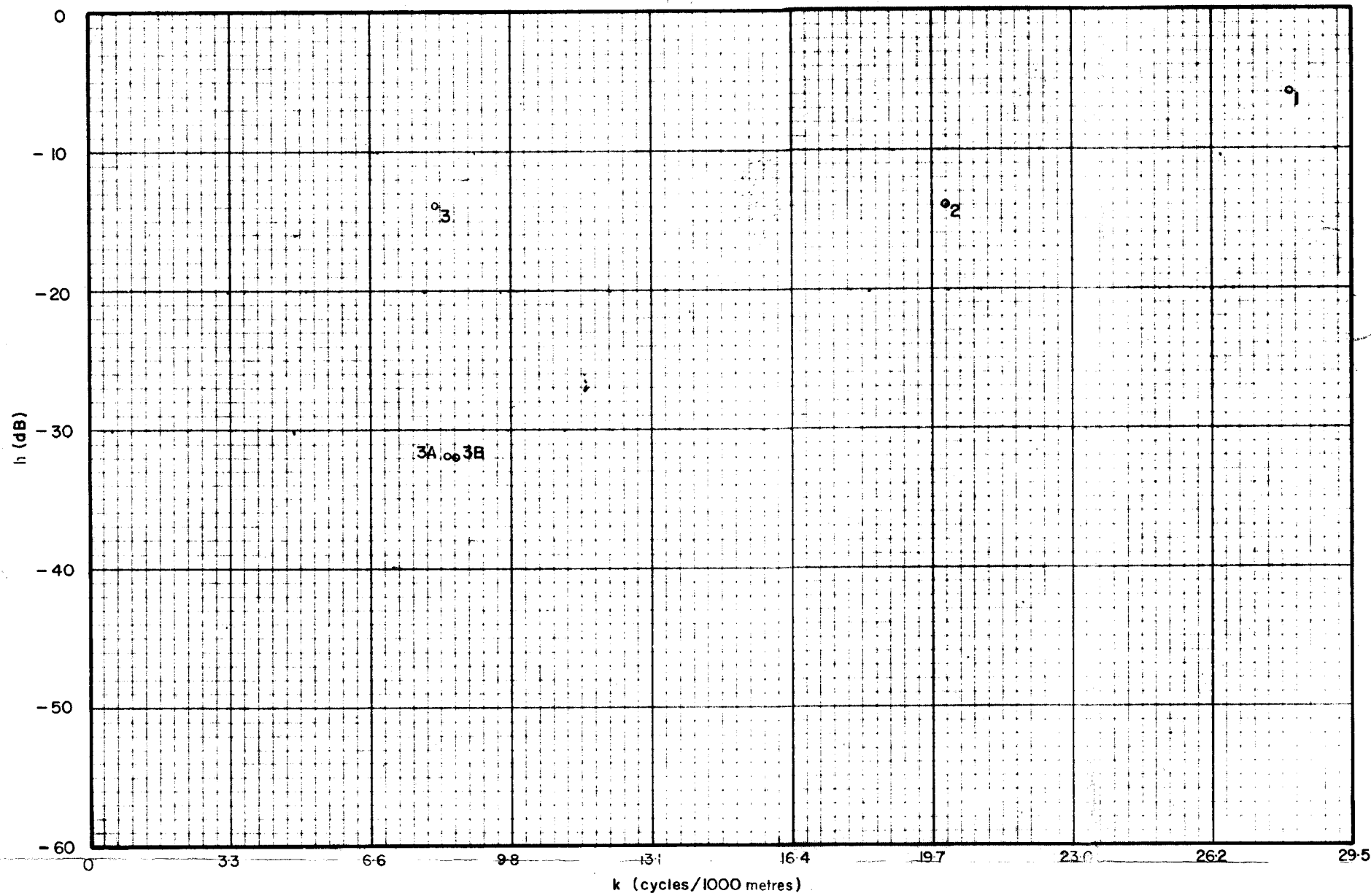
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156/B3-21



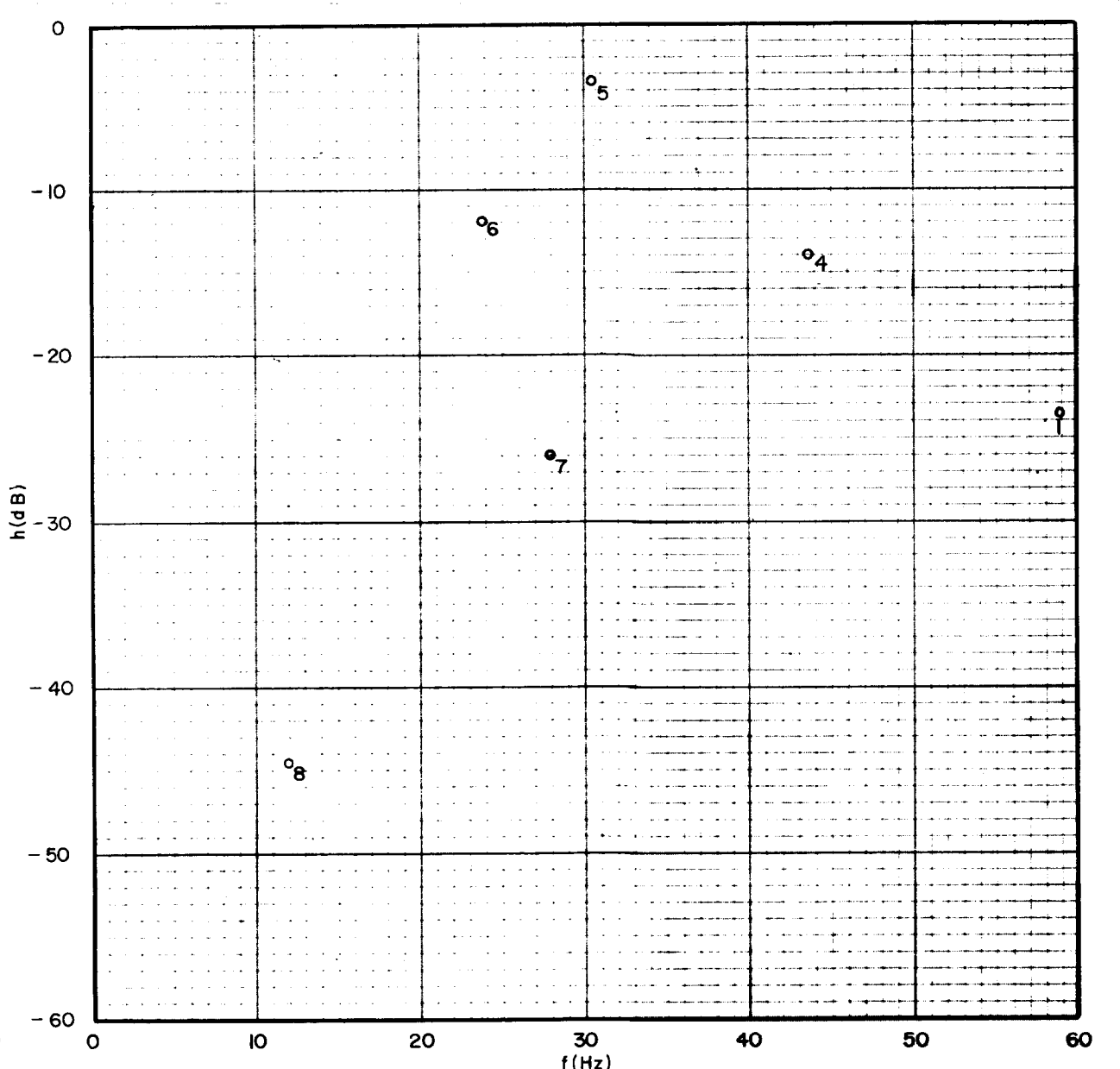
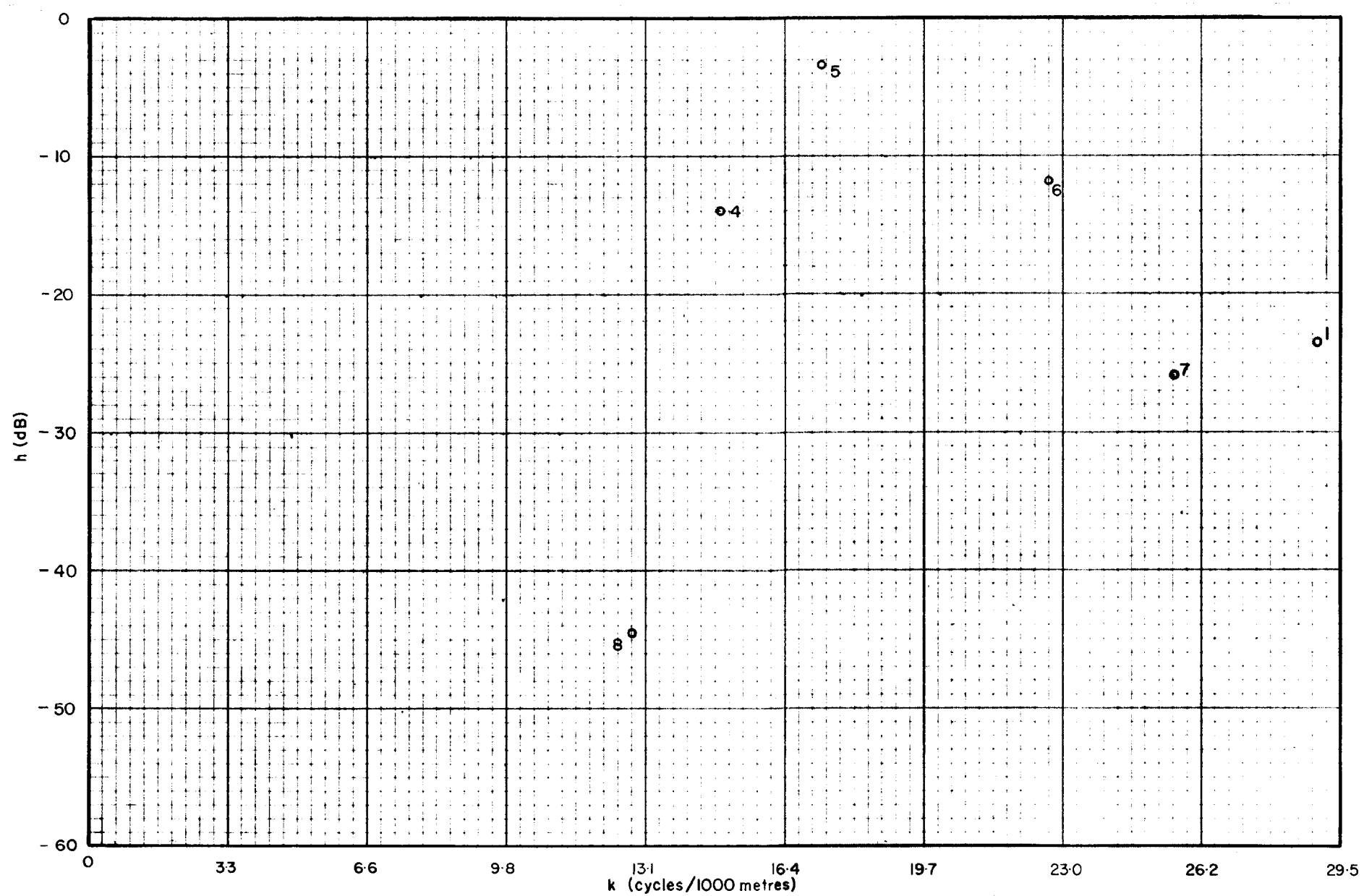
V=Velocity (m/s)
 f=Estimated Peak Frequency(Hz)
 A=Amplitude in dB

TRAVERSE HS 2
 NOISE ANALYSIS SP1487 B



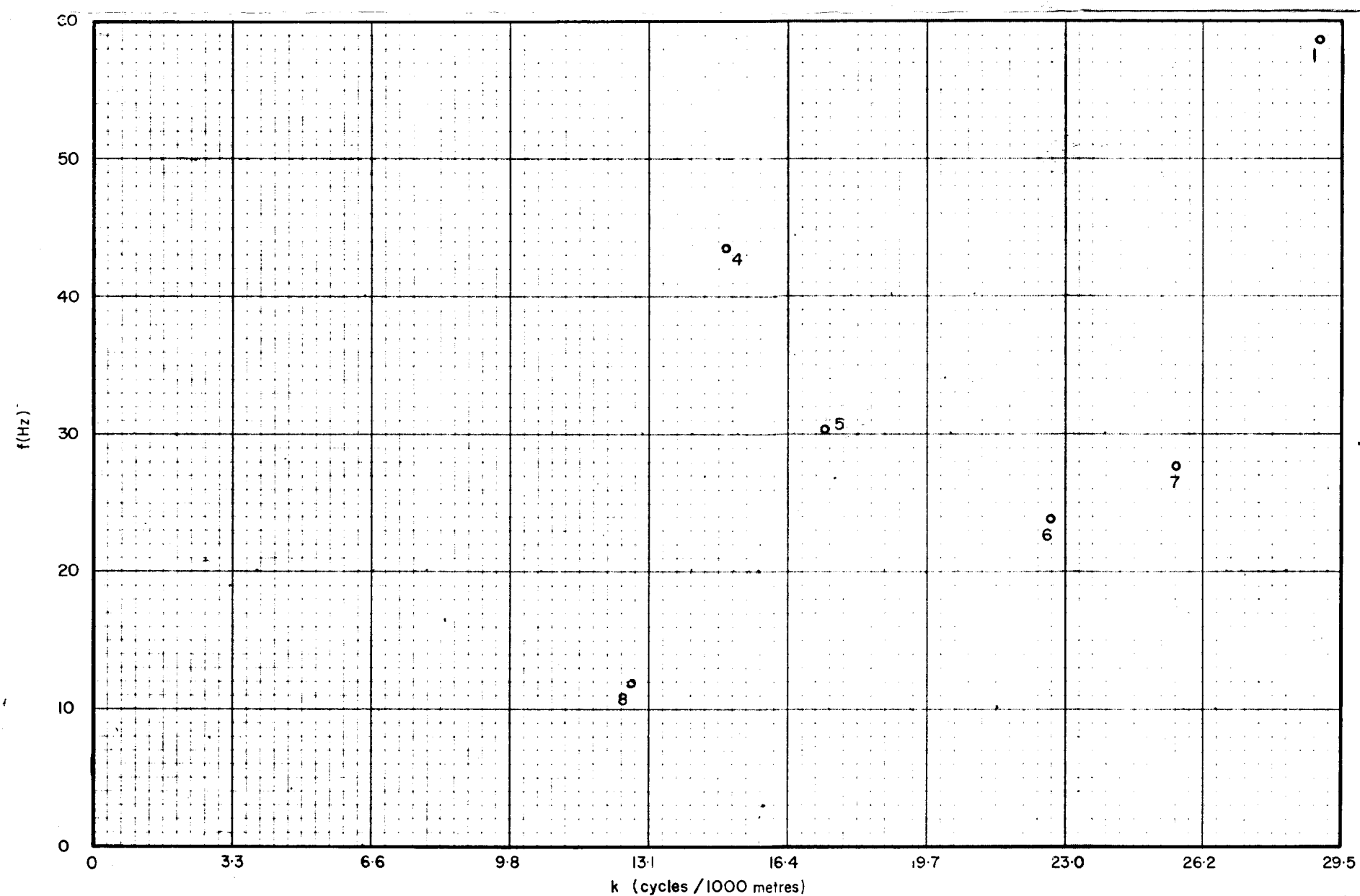
h = Relative Amplitude
k = Wave number
f = Frequency

GEOPHONES EVS 8B-4.5 Hz
PREFILTERS OUT

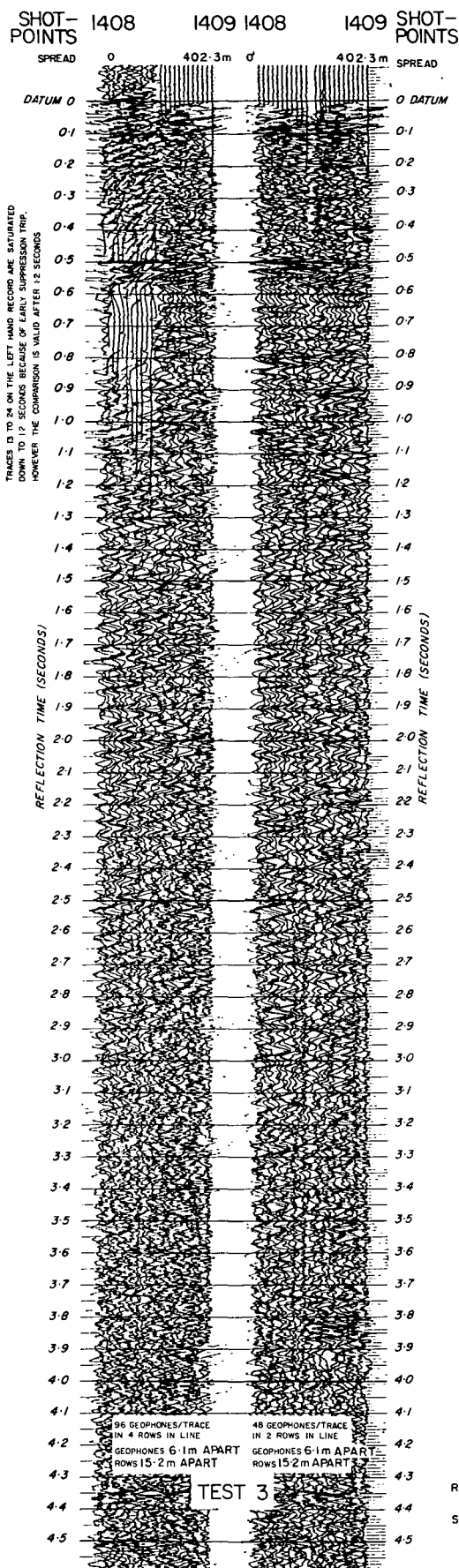


h = Relative Amplitude
k = Wave number
f = Frequency

GEOPHONES HSJ - 14 Hz
PREFILTERS 18 Hz 12 dB/o



TRAVERSE HS 2
NOISE ANALYSIS-SP1487 B



CORRECTED RECORD SECTIONS

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000B

Filters : PREFILTERS 21Hz, 24dB/o

A.G.C. : OFF KO-K92

Gain Initial : -60

Final : Max.

Geophones : HSJ-14Hz

Geophone pattern :

as indicated

Shot-hole pattern :

9 holes, 15.2m apart in line

Depth 24.4/27.4m

Charge 9x18.1kg.

PLAYBACK INFORMATION

Filters : 1/20-1/60

A.G.C. : Med.

Gain Initial : -40

Final : -20

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

$V_0 = 365.8 \text{ m/s}$ (CONSTANT)

HORIZONTAL SCALE

as indicated

Record No. 1974/157

TRAVERSE HS1
GEOPHONE PATTERN COMPARISON

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources
Playback Centre SIE MS 42

156/B3-30 A

CORRECTED
RECORD SECTIONS

RECORDING INFORMATION

Magnetic Recorder PMR-20

Amplifiers : 7000B

Filters PREFILTERS 21Hz, 24dB/o

A.G.C. : OFF KO-K92

Gain Initial : -60

Final : -20

Geophones : HSJ-14Hz

Geophone pattern

24/trace, in 2 rows in line

Geophones 61 m apart

Rows 15.2 m apart

Station interval 4471 m

Shot-hole pattern

as indicated

PLAYBACK INFORMATION

Filters : 1/20-1/60

A.G.C. : Med.

Gain Initial : -40

Final : -20

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

$V_0 = 3658$ m/s (CONSTANT)

HORIZONTAL SCALE

as indicated

TRAVERSE HSI

SHOT-HOLE PATTERN COMPARISONS

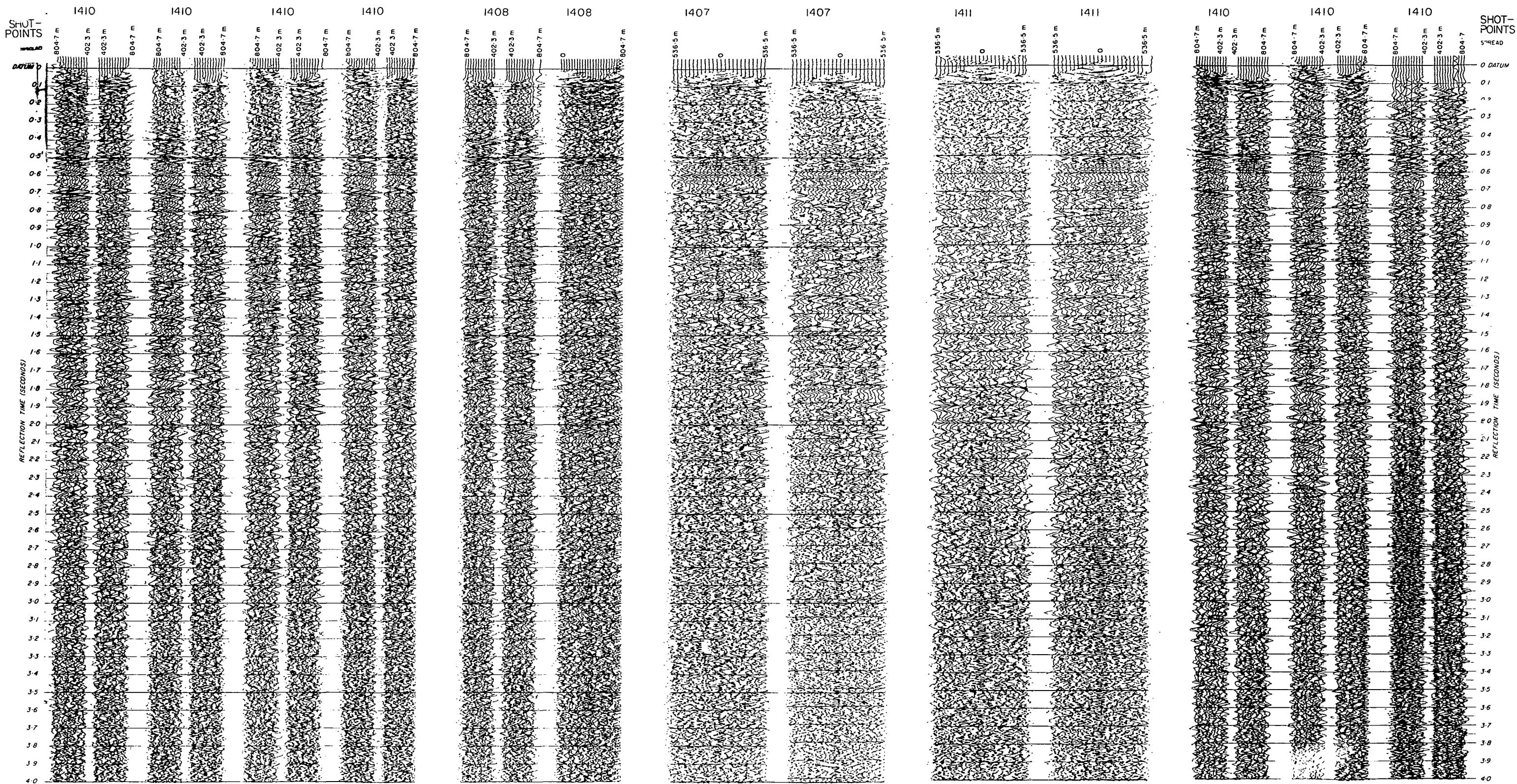
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Playback Centre SIE MS 42

Record No. 1974/157

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9 HOLES IN LINE
15.2 m SPACING
DEPTH 26.2/32.0 m
CHARGE 9 x 18.1 kg

7 HOLES IN LINE
15.2 m SPACING
DEPTH 29.0/32.0 m
CHARGE 7 x 22.7 kg

5 HOLES IN LINE
30.2 m SPACING
DEPTH 27.7/32.0 m
CHARGE 5 x 31.8 kg

2 ROWS OF 5 HOLES IN LINE
30.2 m SPACING BETWEEN ROWS
30.2 m SPACING BETWEEN HOLES
DEPTH 30.2/32.0 m
CHARGE 10 x 15.9 kg

7 HOLES IN LINE
15.2 m SPACING
DEPTH 28.3/32.0 m
CHARGE 7 x 22.7 kg

2 ROWS OF 5 HOLES IN LINE
30.2 m SPACING BETWEEN ROWS
21.3 m SPACING BETWEEN HOLES
DEPTH 28.6/32.0 m
CHARGE 10 x 15.9 kg

7 HOLES IN LINE
15.2 m SPACING
DEPTH 31.1/36.6 m
CHARGE 7 x 31.8 kg

9 HOLES IN LINE
15.2 m SPACING
DEPTH 32.0/36.6 m
CHARGE 9 x 31.8 kg

7 HOLES IN LINE
21.3 m SPACING
DEPTH 32.0/36.6 m
CHARGE 7 x 31.8 kg

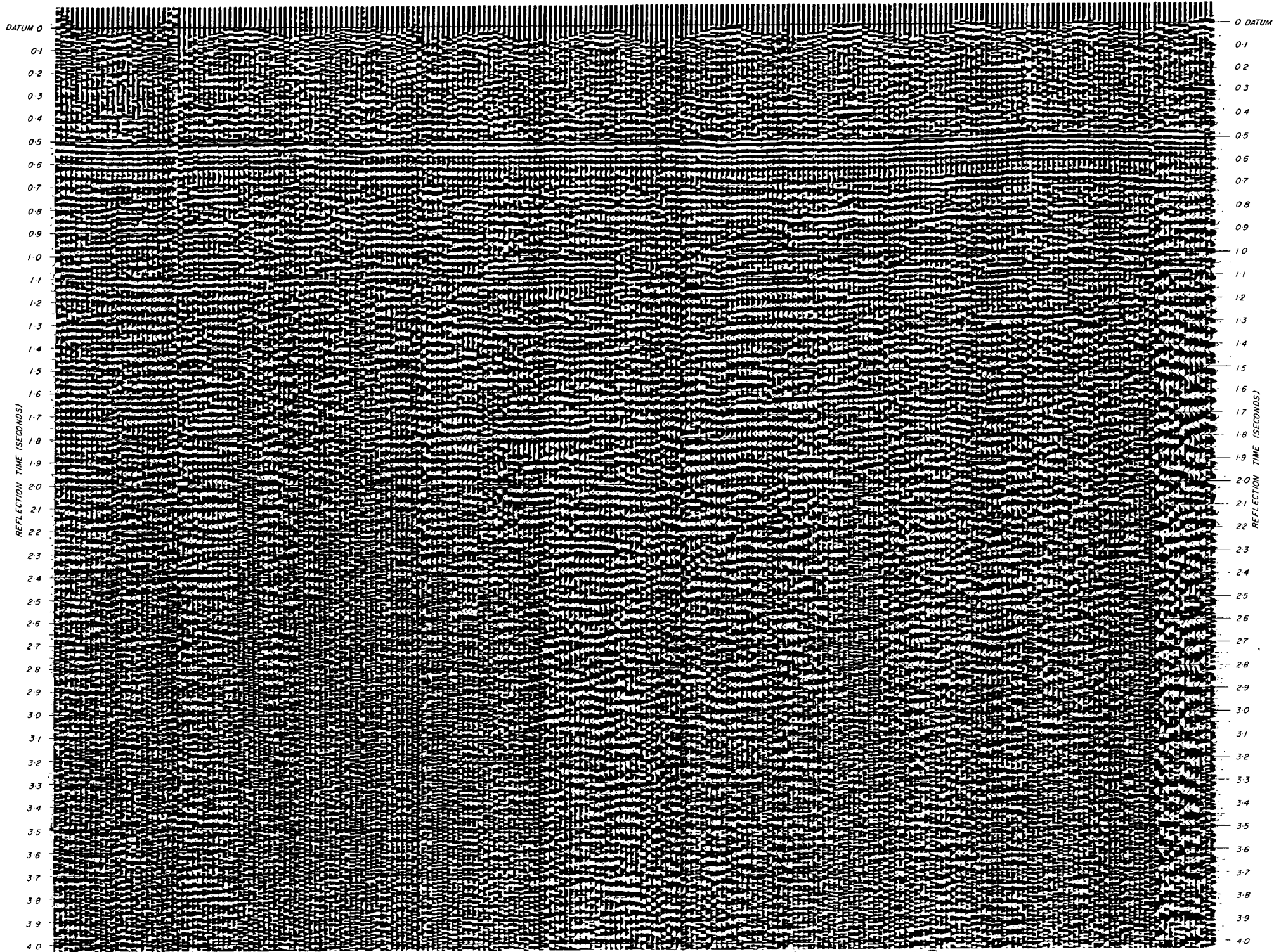
2 ROWS OF 7 HOLES IN LINE
30.2 m BETWEEN ROWS
21.3 m SPACING BETWEEN HOLES
DEPTH 15.2/18.3 m
CHARGE 14 x 15.9 kg

9 HOLES IN DIAMOND PATTERN
21.3 m SPACING
DEPTH 21.1/31.1 m
CHARGE 9 x 18.1 kg

16 HOLES IN DIAMOND
21.3 m SPACING
DEPTH 27.7/32.0 m
CHARGE 16 x 10.2 kg

36 HOLES IN DIAMOND
PATTERN 12.2 SPACING
DEPTH 3.4/4.6 m
CHARGE 36 x 4.5 kg

SHOT-POINTS 1403 1404 1/3 1405 2/3 1407 1408 1/3 1409 2/3 1411 1412 1/3 1413 2/3 1415 SHOT-POINTS



CORRECTED
RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000B

Filters : PREFILTERS 21Hz, 12dB/o

A.G.C. : Med. K0-K92

Gain Initial : -60

Final : Various -10 to -30

Geophones : HSJ-14 Hz

Geophone pattern :

48/trace, in 2 rows in line

Geophones 6.1 m apart

Rows 15.2 m apart

Station interval 44.7 m

Shot-hole pattern :

As indicated

PLAYBACK INFORMATION

Filters : 1/20-1/60

A.G.C. : Med.

Gain Initial : -40

Final : -20

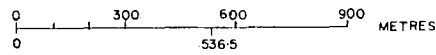
Trip delay : 0s

Compositing : Nil

VELOCITY INFORMATION

Va=3658 m/s (CONSTANT)

HORIZONTAL SCALE



TRAVERSE HSI
SP1403-SP1415

RECORDED BY : Seismic Party No. 2

SECTION BY : Bureau of Mineral Resources
Playback Centre SIE MS 42

Record No. 1974/157

156/B3-26

7 HOLES, 21.3 m APART IN LINE
DEPTH 31.4/36.6 m
CHARGE 7 x 31.8 kg

14 HOLES IN 2 ROWS IN LINE
HOLES 21.3 m APART
ROWS 15.2 m APART
DEPTH 15.8/18.3 m
CHARGE 14 x 15.9 kg

9 HOLES, 15.2 m APART IN LINE
DEPTH 32.3/36.6 m
CHARGE 9 x 27.2 kg

9 HOLES, 15.2 m APART IN LINE
DEPTH 31.1/36.6 m
CHARGE 9 x 27.2 kg

7 HOLES, 15.2 m APART IN LINE
DEPTH 31.1/36.6 m
CHARGE 7 x 31.8 kg

14 HOLES IN 2 ROWS IN LINE
HOLES 21.3 m APART
ROWS 15.2 m APART
DEPTH 15.2/18.3 m
CHARGE 14 x 15.9 kg

14 HOLES IN 2 ROWS IN LINE
HOLES 21.3 m APART
ROWS 15.2 m APART
DEPTH 9.1/18.3 m
CHARGE 14 x 15.9 kg

14 HOLES IN 2 ROWS IN LINE
HOLES 21.3 m APART
ROWS 15.2 m APART
DEPTH 15.2/18.3 m
CHARGE 14 x 15.9 kg

13 HOLES IN 2 ROWS IN LINE
HOLES 21.3 m APART
ROWS 15.2 m APART
DEPTH 15.5/18.3 m
CHARGE 13 x 15.9 kg

14 HOLES IN 2 ROWS IN LINE
HOLES 21.3 m APART
ROWS 15.2 m APART
DEPTH 15.5/18.3 m
CHARGE 14 x 15.9 kg

CORRECTED
RECORD SECTION

SHOT-
POINTS

1482

1484²/₃

1486

1487¹/₃

1488²/₃

1490

1492²/₃

1494

1495¹/₃

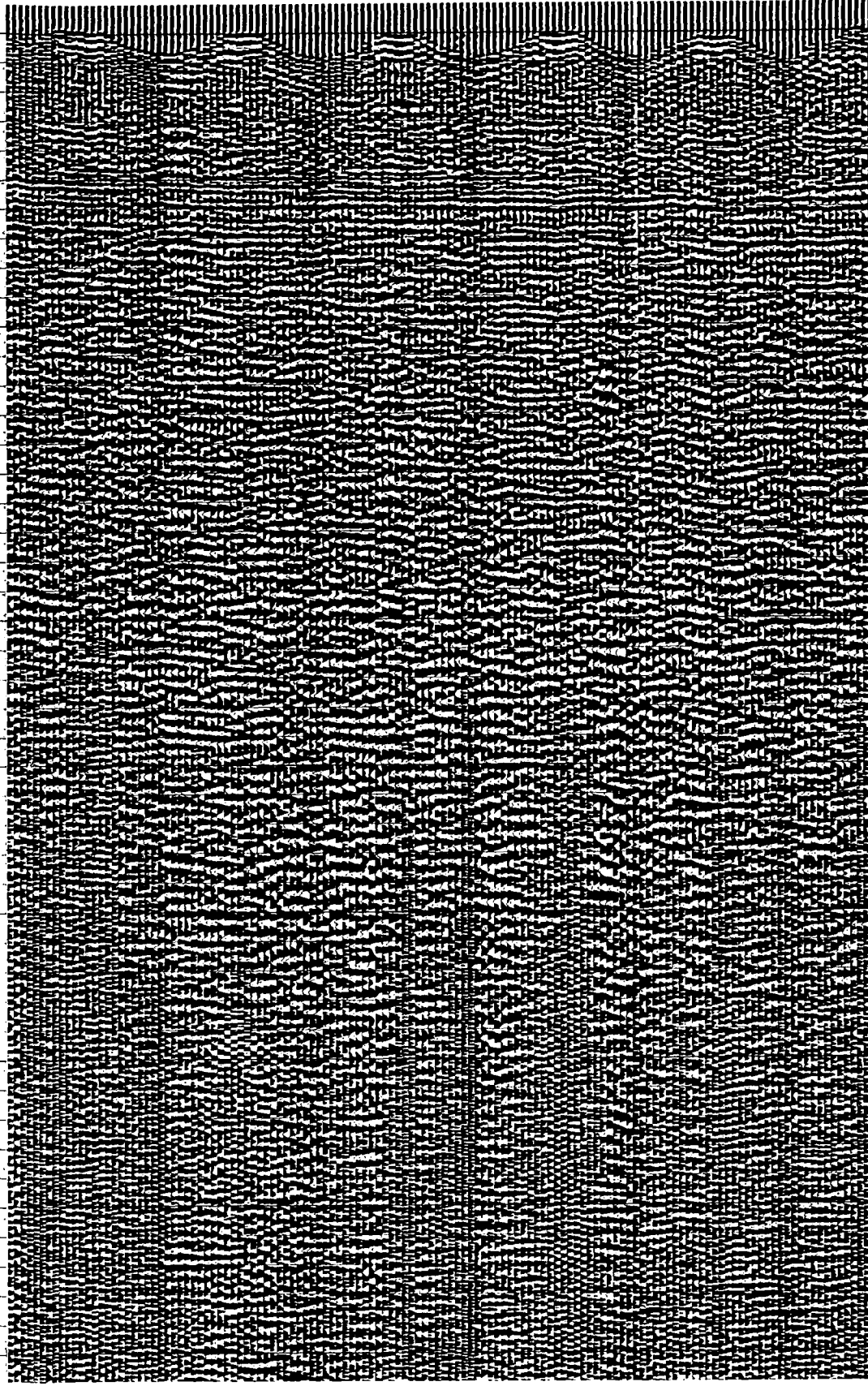
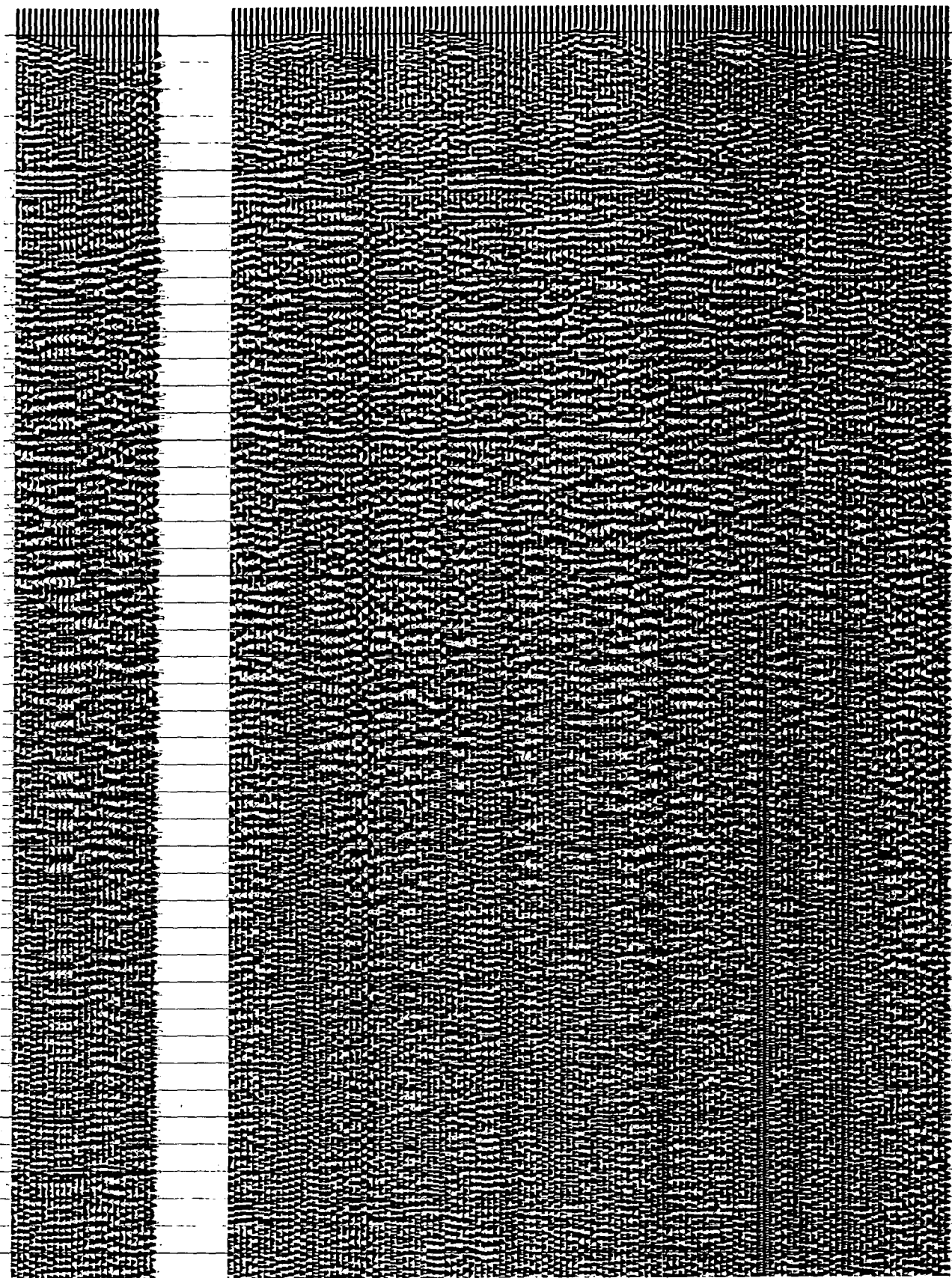
1496²/₃

1498

1499¹/₃

SHOT-
POINTS

DATUM 0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4.0
4.1
4.2
4.3
4.4
4.5



0 DATUM
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4.0
4.1
4.2
4.3
4.4
4.5

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: PREFILTERS 21Hz, 12dB/o
KO-K92

A.G.C.: Med.

Gain Initial: -50 to -57

Final: -10

Geophones: HSJ-14Hz

Geophone pattern:

24/trace, 6.1m apart in line
Station interval 44.7m

Shot-hole pattern:

7 holes, 21.3m apart in line
Depth 18.3m
Charge 7x13.6 kg
SP1484²/₃ and 1486.

7 holes, 18.3m apart in line

PLAYBACK INFORMATION

Filters: 1/20 - 1/60

A.G.C.: Med.

Gain Initial: -40

Final: -20

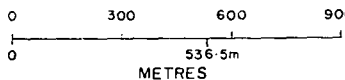
Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

Va = 3658 m/s (CONSTANT)

HORIZONTAL SCALE



TRAVERSE HS 2
SP 1482-SP1499¹/₃

RECORDED BY: Seismic Party No. 2

SECTION BY: Bureau of Mineral Resources
Playback Centre SIE MS 42

Record No. 1974/157

156/B3-27

SHOT-
POINTS

1601 $\frac{1}{3}$

1602 $\frac{2}{3}$

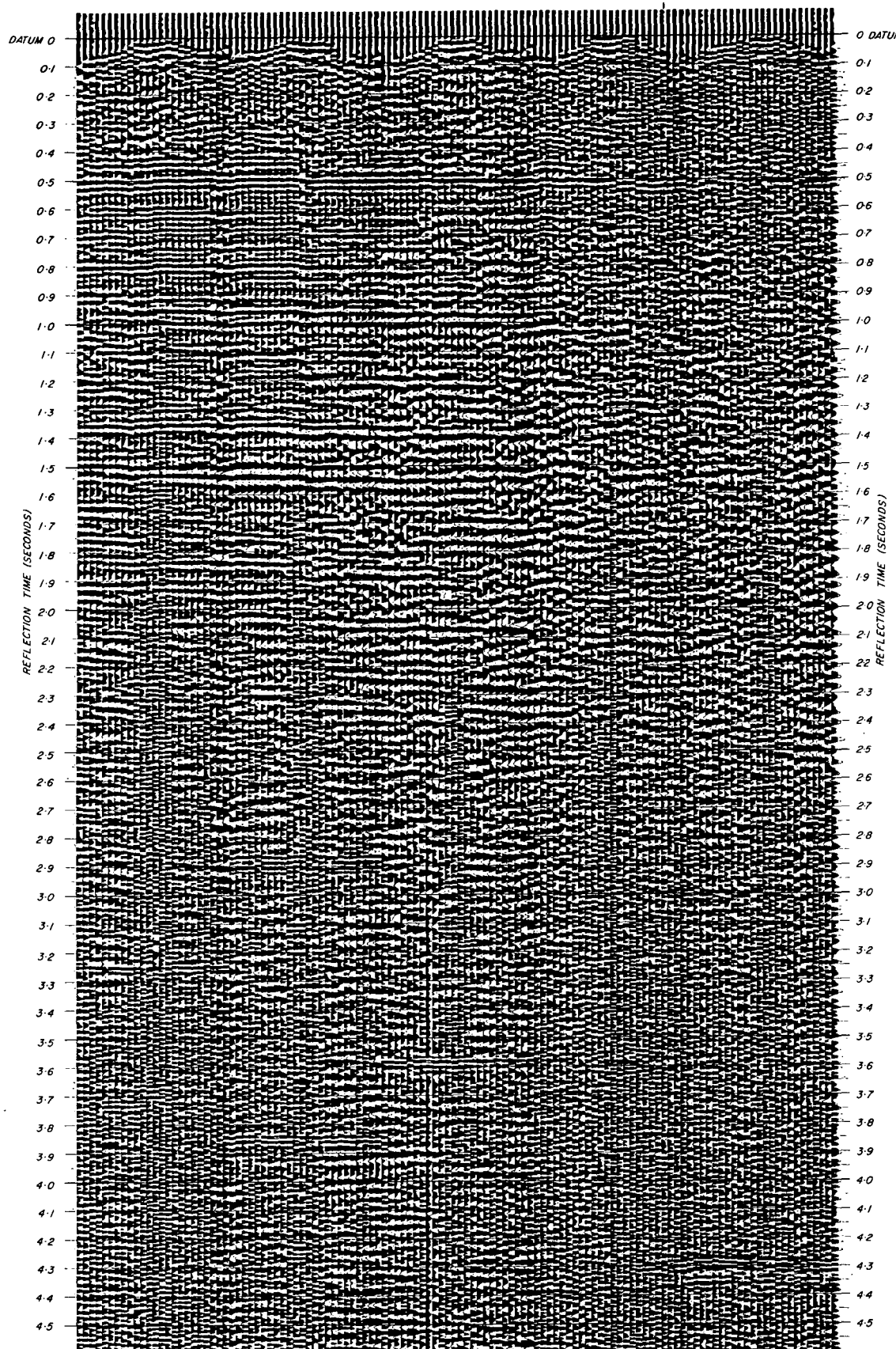
1604

1605 $\frac{1}{3}$

1606 $\frac{2}{3}$

SHOT-
POINTS

CORRECTED
RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: PREFILTERS 21Hz 12dB/o

A.G.C.: Med. KO-K92

Gain Initial: -60

Final: -20

Geophones: HSJ-14Hz

Geophone pattern:

24/trace, 6.1m apart in line
Station interval

Shot-hole pattern:

7 holes, 21.3m apart in line
Depth 18.3m
Charge 7x13.6kg

PLAYBACK INFORMATION

Filters: 1/20-1/60

A.G.C.: Med.

Gain Initial: -40

Final: -20

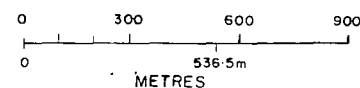
Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

Va = 3658 m/s (CONSTANT)

HORIZONTAL SCALE



SYDNEY BASIN

TRAVERSE HS3

SP1601 $\frac{1}{3}$ - SP1606 $\frac{2}{3}$

RECORDED BY: Seismic Party No. 2

SECTION BY: Bureau of Mineral Resources

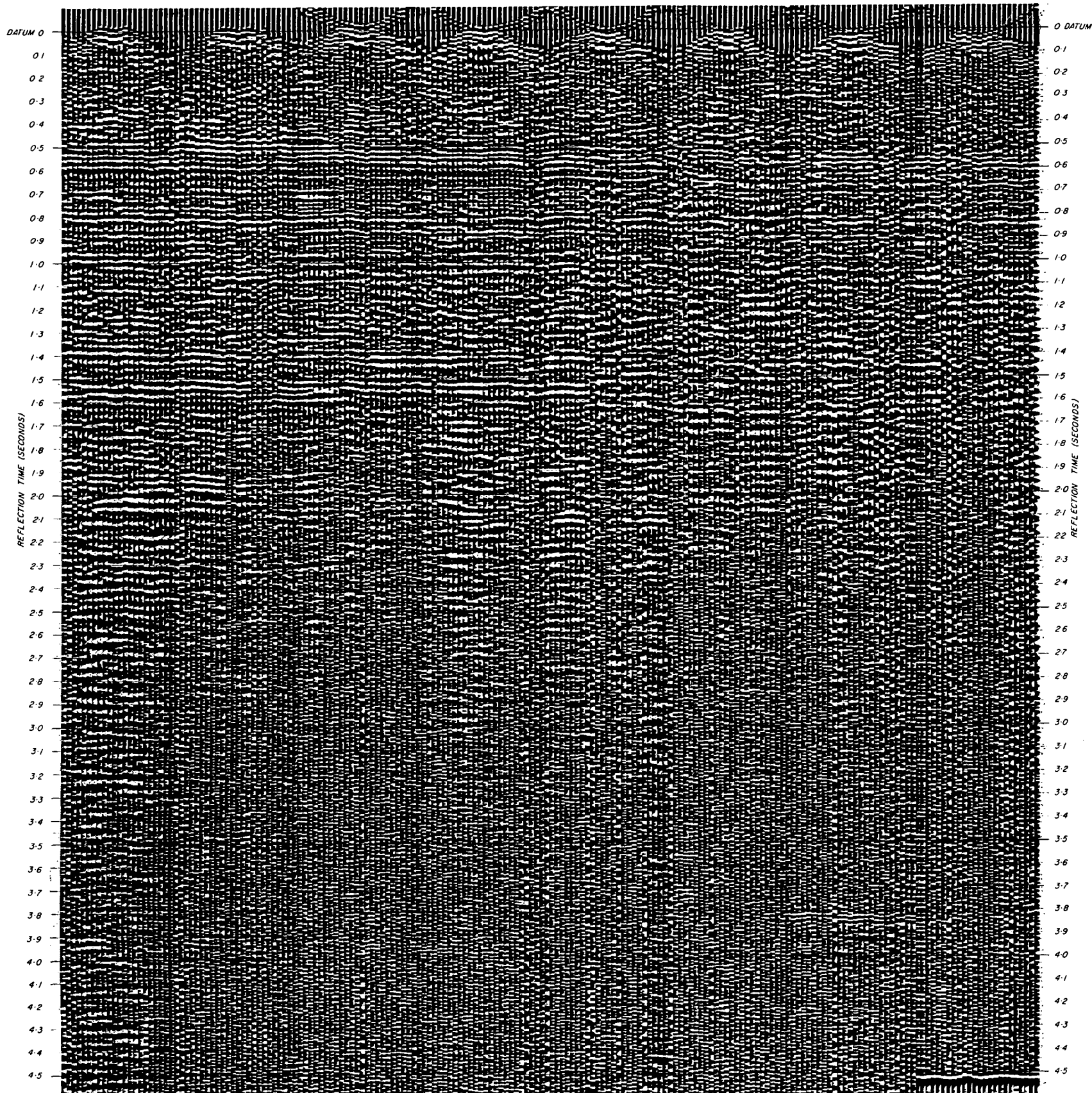
Playback Centre SIE M5 42

Record No. 1974/157

156/B3-28

SHOT-POINTS 1698 $\frac{2}{3}$ 1700 1701 $\frac{1}{3}$ 1702 $\frac{2}{3}$ 1704 1705 $\frac{1}{3}$ 1706 $\frac{2}{3}$ 1708 SHOT-POINTS

CORRECTED
RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: PREFILTERS 21Hz, 12dB/o

A.G.C.: Med. KO-K92

Gain Initial: -60

Final: -20

Geophones: HSJ-14 Hz

Geophone pattern:

48/trace, in 2 rows in line

Geophones 6.1m apart

Rows 15.2m apart

Station interval 44.7m

Shot-hole pattern:

13 holes, 10.7m apart in line

Depth 18.3m, Total charge 204.1 kg

SP1701 $\frac{1}{3}$, 14 holes in 2 rows in line

Rows 30.5m apart, holes 21.3m apart

SP1708, 7 holes, 21.3m apart in line

PLAYBACK INFORMATION

Filters: 1/20-1/60

A.G.C.: Med.

Gain Initial: -40

Final: -20

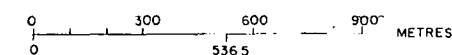
Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

Va = 3657.6 m/s (CONSTANT)

HORIZONTAL SCALE



Record No. 1974/157

TRAVERSE HS4

SP 1698 $\frac{2}{3}$ - SP 1708

RECORDED BY: Seismic Party No 2

SECTION BY: Bureau of Mineral Resources

Playback Centre SIE MS 42

156/B3-29