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SYDNEY BASIN EXPERIMENTAL SEISMIC SURVEY FOR COMPARISON WITH A "VIBROSEIS" SURVEY, NSW 1965

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1. Introduction

In accordance with the programme for accelerated oil search, the B.M.R. (Bureau of Mineral Resources) employed a contractor during 1964, to demonstrate the performance of the "Vibroseis" in various problem areas of the Otway and Sydney Basins. The objectives of this experimental survey were to show the capabilities of the method in difficult areas, to assess the cost for comparison with shothole seismic methods in these areas, and to assess its potential as a new method. The Hawkesbury Sandstone problem in the Sydney Basin was amongst the problems submitted to the "Vibroseis" method.

A conventional shot-hole seismic survey was to follow in order to obtain a valid comparison of the results and costs of production techniques used in the two methods. The B.M.R. No. 2 Seismic Party carried out the Sydney Basin experimental survey from September to November 1965 which is the subject of this report.

Seismic work in the Sydney Basin has been generally restricted in the past, to areas which have no Triassic Hawkesbury Sandstone on the surface. Areas covered by this formation have been classified as problem areas due to the rugged nature of the outcrops, costly drilling and poor record quality. Since the formation covers a large potentially gas or oil producing area near Sydney, it is clear that a considerable amount of seismic work may in future be required on the Hawkesbury Sandstone, if the Sydney Basin is to be adequately explored.

The experimental programme has been carried out along traverses H.S.1 to H.S.4, used by the "Vibroseis" party in 1964 (Plate No. 1). These traverses are located (a) H.S.1 and H.S.2 near Kulnura and (b) H.S.3 and H.S.4 in the Grassy Hills area.

2. Geology

The Sydney Basin is bounded on the west and south-west by lower and middle Palaeozoic sediments, intruded by granites (Plate No. 2). To the north-west it is cut off from the outcropping Carboniferous sediments by the Hunter Fault. The extent of the basin under the Pacific Ocean to the east is unknown, but aeromagnetic results suggest that there is a structural high offshore; however, as the Gerrigong Volcanics to the south produce a false magnetic basement, the structural high offshore could be due to an extension of these volcanics.

The main stratigraphy of the basin is summarised below:-

	Formations	South-East	Central and North
		Maximum Known Thickness	
TRIASSIC	(Wianamatta Gp (shale and sandstone	800'	Same
	(Hawkesbury Sandstone (massive quartz sandstone	900'	Same
	(Narrabeen Gp	2000-2500'	Same
PERMIAN	(Upper Coal Measures	1000'	5500'
	(Gerrigong Volcanics	1000' ±	Not known
	(Upper Marine	3000-3500'	5000'
	(Lower Coal Measures	135'	1000'
	(Lower Marine	Not Present	6000' Volcanics at base
CARBONIFEROUS	(Upper Kuttung	Not Present	4300' Glacial
	(Lower Kuttung Volcanics	Not Present	2200' and Volcanics

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, hard, massive and quartzitic, is similar in places to that of the sandstone in the underlying Narrabeen Group.

3. Previous Seismic Work

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

Fair results were obtained on the Wianamatta Shale and Newcastle Coal Measures but poor results were obtained in test areas on the Hawkesbury Sandstone. At Dural, shooting in Hawkesbury Sandstone, some indications of structure to 3000-4000 ft were obtained using 10 geophones per trace at 22.5 ft intervals and single holes drilled to 100 to 200 ft with 25 lb charges. The record quality was generally poor and no reflections were recorded from deeper in the section.

Since 1957, a considerable number of seismic surveys have been conducted throughout the basin. These have generally been confined to areas with little or no Hawkesbury Sandstone on the surface. In areas away from Hawkesbury Sandstone outcrops, fair quality results have generally been obtained using up to 12 geophones per trace with up to 20 ft. between geophones and with one deep hole to 100 to 200 ft or up to 9 shallow holes in diamond patterns. Only poor results have been obtained in some areas despite considerable testing with different size charges, varying the number and spacing of geophones and shot holes and depths of holes. It has been concluded that these poor reflection areas are probably highly faulted.

Seismic work extending on to the rugged Hawkesbury Sandstone generally gave poor but usable information on the shallow part of the section, and unusable results below about 6000 ft., despite experimentation with single deep holes, multiple holes, charge size, long offsets and geophone patterns.

The experimental "Vibroseis" survey was carried out in Hawkesbury Sandstone outcrops in the Kulnura and Grassy Hills areas during a 6 weeks period from August to October 1964.

The results of "Vibroseis" noise test recordings on the Hawkesbury Sandstone 1 traverse about 3 miles south of Kulnura No. 1 bore indicated that a high velocity, high amplitude, first break arrival was the most important organised noise event. After considerable experimentation with different offsets, sweep frequencies, number of sweeps and pattern lengths, for source and detectors, a transposed technique was adopted with source patterns 600 ft long and detector patterns 600 ft long by 200 ft wide with sweep frequency in the range 10-40 c.p.s.(mean 25 c.p.s).

Good quality reflections were recorded between 0.5 and 0.7 seconds using this transposed technique. The quality of deeper information at about 1.7 sec was improved by increasing the pattern lengths to 1000 ft and using longer vibrator to geophone offsets. The improvement in signal/noise ratio for the deeper events was achieved at the cost of severe attenuation of the shallower reflections.

The technique found to be applicable for recording south of Kulnura was used for recording on the Hawkesbury Sandstone 2 traverse along a twisting road which passed the Kulnura No. 1 bore. Fair quality reflections are evident to approx. 1.4 sec and the Kulnura anticlinal structure is shown to extend in low relief through the section. As for the H.S.1 traverse a choice appeared to exist with respect to recording the deeper information at the cost of severe attenuation of the shallow reflections.

On both Hawkesbury Sandstone 1 and 2 traverses it was found that by using a 10-40 c.p.s. sweep and appropriate equipment filters the level of troublesome 50 c.p.s. pick-up was greatly reduced. On previous shot-hole surveys in the Kulnura as well as other Hawkesbury Sandstone areas 50 c.p.s. pick-up completely swamped the latter half of the seismic records, beyond 0.7 sec.

A test was made of the applicability of the best recording methods used at Kulnura to recordings in the Grassy Hills area on outcropping Hawkesbury Sandstone using the transposed technique found for Kulnura. Fair quality reflections were obtained on the Hawkesbury Sandstone 3 traverse and at the western end of the Hawkesbury Sandstone 4 traverse, to approx. 1 sec reflection time, with poorer quality events evident to approx. 1.6 sec reflection time. The reflection quality deteriorated towards the eastern end of the Hawkesbury Sandstone 4 traverse which was located on a narrow Hawkesbury Sandstone ridge with deep steep gorges on either side.

The "Vibroseis" results on the Hawkesbury Sandstone showed some improvement on those obtained by previous shot hole work. This improvement may be attributed to the use of longer source and detector patterns - 600 ft to 1000 ft compared with approx. 240 ft in shot hole work and to the use of a 10-40 c.p.s. sweep, thereby effecting a reduction in 50 c.p.s. power line interference which appeared in most conventional records in the area.

Information on vertical velocities in the sedimentary section in the Sydney Basin, has been obtained from sonic logs, t - Delta t analyses and velocity shooting. The velocity relationship in the Permian section established from the sonic logs from Loder No. 1 and East Maitland No. 1 wells is $V = 12,000 + 0.6d$. In the northern part of the basin a constant velocity $V_a = 13,000$ ft/sec derived from t - Delta t analyses was used for reflection plotting. At Woronora and Camden a constant velocity $V_a = 12,000$ ft/sec was found to be reasonable in the section at least to the top of the Upper Marine sequence. The results of the Vibroseis survey were interpreted using the velocity function from East Maitland No. 1. The average subweathering velocity in the Hawkesbury Sandstone was estimated to be about 10,000 ft/sec.

4. Objectives and Programme

The objective for the experimental shothole seismic survey was to obtain a comparison between the shothole and Vibroseis techniques in areas of Hawkesbury Sandstone cover, with regard to both quality of data and operational costs.

The results of the Vibroseis experimental survey in 1964 were an improvement on those of previous shothole seismic surveys. However these previous surveys were conducted using fairly simple techniques. An attempt therefore, should be made to approach a production technique, capable of giving results at least of comparable quality to those of the Vibroseis survey, by a logical and detailed programme of experimentation.

The results and costs of the production shooting are to be compared with those of the "Vibroseis" survey, to provide an assessment of the relative merits of the shothole and "Vibroseis" method in this area. These will be discussed in a report to be published later, comparing the two methods. This present report is concerned only with the results obtained using the shothole method. The programme consisted: (a) in preliminary testing which was designed to measure physical conditions, (b) in experimental recording which was designed to study the various recording parameters, (c) in production recording which was designed to find an acceptable production technique. These three phases of the programme are discussed in the next chapter.

5. Results

5-1 Preliminary Testing

The preliminary testing consisted of an up-hole survey at shot point 1409A and a noise analysis at S.P. 1409B on Traverse H.S.1; and a noise analysis on H.S.2 at S.P. 1487B.

5-1-1 Up-Hole Survey

A hole was drilled at S.P. 1409A to a depth of 240'. Drilling was moderately difficult; a continuous section of sandstone was encountered with beds of various thicknesses varying in hardness from soft to very hard. The water table was found to be at 86'. A 2640 foot spread was laid out on one side of the shotpoint in the hope of recording some signal and thus determining the optimum shooting depth. A geophone pattern of two parallel lines 25' apart, each of 24 geophones 20' apart, was used. This pattern, designed to eliminate some of the noise, was an educated guess based on previous results obtained in this area. A charge of 40lb was used for all recordings with the exception of the very shallow ones.

Plate No. 3 shows the time-depth graph. Down to 10' the velocity is about or less than 1000'/sec, 5000'/sec down to 80', 8,300'/sec down to 155' and 12,500'/sec down to the bottom. The energy (as indicated by the LLI curve) reaches about 10 millivolts with the first arrivals and decreases very rapidly to 30 microvolts in about 1.2 sec. The charges were very lightly tamped to keep the hole open for the subsequent recordings.

Some signal can be observed at about 500 and 600 milliseconds and at about 900 milliseconds. It is clearly visible on the record shot at a depth of 105/115', which corresponds to a thin bed of very hard sandstone. For shots above and below this depth, the quality of the signal deteriorates very rapidly. It is very poor on the recordings at 80'/90' and 130'/140'. These results indicate that the optimum recording depth is in the vicinity of 100' and is probably somewhat critical. These records show a predominance of low frequencies. 50 c.p.s. pick-up becomes quite apparent for input levels less than 30 microvolts. The level of the background noise is quite high.

5-1-2 Noise Analysis

A 3150' spread with geophones bunched every 30' was used to record the noise tests. Two perpendicular spreads 600' long, of 24 traces, with 8 bunched geophones every 12.5' were laid, one 480' and the other 1320' away from the shot point, in order to record transverse noise. The charge was 40lb at a depth of 80'. These tests were recorded twice in order to study the attenuation of the noise due to the instruments only: once with geophones having a resonant frequency of 4.5 c.p.s. and with filters 0 - 120K and once with the anticipated field technique of geophones having a resonant frequency of 14 c.p.s., filters 0 - 92K and pre-filters 18 c.p.s. with a slope of 12 db per octave. The gain of the amplifiers was increased with the distance but a record of it was kept so as to measure the absolute amplitude. The plates shown were played-back with A.V.C. to enhance the noise however, the data were collected from records played-back with constant gain.

5-1-2-1 H.S.1 S.P. 1409B

Plates No. 4 and 5 show the recordings of the Noise Tests with 4.5 c.p.s. geophones and 14 c.p.s. geophones. Plates No. 6 and 7 show the corresponding time-distance graphs and frequency and wave-number spectra.

The first refracted arrivals have a velocity of 12,300'/sec. Three types of noise can be observed. (a) A wave-train with a velocity of about 6000'/sec and a frequency of about 30 c.p.s. (events 6, 7, 8). (b) An apparently low frequency dispersive wave-train of relatively high amplitude, the velocity averaging 3500'/sec and the frequency 10 c.p.s. (events 1, 2, 1A, 2A). (c) A very low velocity wave-train with a velocity of about 1300'/sec to 1700'/sec and a frequency of about 20 c.p.s. (events 3 and 4). Event 9, observed only on this recording, with an apparent velocity of 18,250'/sec and a frequency of 36 c.p.s. has been identified as possible signal. A consideration of the move-out would preclude that assumption, however, the position of the event on the frequency-wave number graph strongly confirms it. It can be observed at a distance from 2000' to 2400' and has a wave-number of 2 c/1000'.

A comparison shows that about half the events can be identified on both recordings. The use of the 14 c.p.s. geophones and of the pre-filters resulted in a shift of both spectra towards higher frequencies and higher wave-numbers. The wave-number cut-off are respectively 2.5 c/1000' and 3.5 c/1,000'. From these results it would appear that a spatial filter designed to have a wave-number cut-off of about 3.5 c/1,000', that is an n.e. of about 300 ("n" being the number of geophones and "e" the spacing between them), would be quite adequate; however, the fact that the lower components are attenuated to the extent that they cannot be visually picked on the high frequency noise test does not necessarily mean that their influence is no longer detrimental. A.O.G. at the time of the survey was currently using a geophone pattern with a wave-number cut-off of 3.3 c/1000' which did not completely attenuate the surface waves. Previous experience indicated that very long patterns must be used on very hard material. With these facts in mind it was decided to begin the testing with patterns having a wave-number cut-off of 2c/1000' which could be reduced if necessary. Subsequent testing with shot-hole patterns, as discussed below, confirmed this view. This is a rather powerful filter and care must be taken to insure that it does not attenuate overmuch reflected signal. If event 9 is signal, its wave-number between the origin and 1760' (the maximum spread length used) is much lower than that measured at 2,000', and will not be strongly attenuated by this filter.

A small amount of transverse-noise was observed on the perpendicular spreads, but it is suspected that on ridges the transverse noise is much more important. The wave-numbers found are 9 and 18 cycles/1.000' and spacing between parallel lines of geophones and shotholes should be designed to attenuate it.

5-1-2-2 H.S.2. S.P. 1487B

Plates 8 and 9 show the sections of the noise recording with 4.5 c.p.s. geophones and with 14 c.p.s. geophones, Plates Nos. 10 and 11 the time-distance graphs and the frequency and wave-number spectra. A low frequency, dispersive surface wave is the main feature with a velocity of 4,000'/sec and a frequency of 10 c.p.s. Another arrival can be observed with a velocity of 6500'/sec and a frequency of about 60 c.p.s. No signal is observed. The wave-number spectrum shows again that the filter should be designed to have a wave-number cut-off of about 2.5 cycles/1000'. No significant transverse noise seems to be present.

5-1-3 Conclusions of the Preliminary Testing

The following conclusions can be reached from a study of the preliminary testing and of the techniques previously tried in this area:

- The depth of the charges seems to be critical.

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- Transmission of energy appears to be one of the major problems and the use of large charges is to be expected.

- The shothole and geophone patterns must be designed to attenuate wave-numbers of about 2.5 cycles/1000'.

- Some transverse noise was recorded, however, it is not as important as expected from the nature of the terrain (ridges).

- There is strong 50 c.p.s. pick-up. Notch filters should be used.

- The background noise is very high. This is due, very likely, to wind in the dense scrub. Even on very calm days, the back-ground noise is high enough so that 20 dbs attenuation have to be used on the ultimate sensitivity. On windy days 30 dbs must be used. If the noise level is higher, operations should be discontinued. A large number of geophones per trace have to be used to cancel this noise.

5-2 Experimental Recording

The main experimental programme was carried out on traverse H.S.1 (plate 14), where the "Vibroseis" experimental programme was initially done. Experiments were conducted where possible under similar conditions and varying only one parameter at a time. However, it was not always possible to do so because of the difficulties of operation inherent to a heavy technique in such a type of terrain, and because the same shot-point location could not be used for valid comparisons too often. This is due possibly to poor energy transmission in sandstone heavily fractured by large charges. Some experimentation was carried out during the production recording, the results, although chronologically later are partly discussed in this chapter.

5-2-1 Recording Instrument Settings

The recording instrument settings were:

- Amplifier filters	0-92K
- Notch filters 50 c.p.s.	on
- A.V.C.	medium
- Pre-suppression	-60 db
- Ultimate sensitivity	-10db to -30db

An attenuation of -20db was mostly used. On rare occasions when the wind was high -30db of attenuation was used. Operations were stopped when a greater amount of attenuation became necessary.

- Pre-filters	21 c.p.s. 24db/octave

Initially 18 c.p.s. -20db/octave was used, but a comparison made with 21 c.p.s. -24db/octave at S.P. 1408A indicated that the low frequency components were strongly attenuated by such a filter. The L.L.I. curves on these comparison records show that an important proportion of energy consists in low frequency noise.

- L.L.I.	Full deflection corresponds to 10 millivolts input

5-2-2 Spread length and offset

The traverses were initially surveyed with a spread length of 1320' corresponding to the original "Vibroseis" spread length. This proved to be unsatisfactory because good production could not be obtained with such a short spread length and because of the danger of ground mixing with a 500' geophone pattern. A 0-2640' spread was recorded at S.P. 1408 to determine the safe maximum spread length. The record shows some discontinuity for the shallow reflections of the end traces, but in general the data does not seem to be harmed by such a long spread, however, it is slightly beyond the maximum permissible spread length for a 500' geophone pattern. A spread length of 1760' was selected as being the most suitable, it is a good compromise between 1320' and 2640' and the ground mixing is not as severe. The traverses were resurveyed accordingly.

The centre traces of the monitors of some of the early records were strongly interfered with by shothole noise. Some of the testing was performed with an offset of 1320' and a spread length of 1320' (Test No. 4, S.P. 1410), to determine how much improvement could be obtained on the centre trace. This technique was abandoned because most of the hole noise could be adequately filtered at the playback, because an offset technique slowed down the operations, and because a spread length of 1320' would have had to be used, any longer spread being beyond the maximum permissible spread length for the geophone pattern used at this offset.

5-2-3 Charge Comparison

The initial experiment at S.P. 1408A, was to compare a total charge of 360 lb with a total charge of 270 lb.

- Record 1A, 40 lb per hole at a depth of 80'/90', 9 holes in-line 50' apart.

- Record 2B, 30 lb per hole at a depth of 80'/90', 9 holes in-line 50' apart.

The heavier charge yielded much better results; the improvement is spectacular and shows without any doubt that heavy charges are an important factor. No record is shown because no magnetic tape was recorded for this test.

At S.P. 1408 a total charge of 350 lb was compared with a total charge of 490 lb.

- Record 1A, 50 lb per hole at a depth of 93'/105', 7 holes in-line 50' apart.

- Record 2A, 70 lb per hole at a depth of 102'/120', 7 holes in-line 50' apart.

Because of the technique used in this case only traces 1 to 12 can be compared, traces 13 to 24 have no common points. There appears to be little energy returns and the quality of both these records is poor. The maximum of the L.L.I. Curve corresponds to an input of one millivolt; at 1.5 sec the level is 30 microvolts. The heavier charge yielded slightly better results but this cannot be considered to be conclusive.

Testing of charge size was done several times during the survey, but not always under fully controlled conditions. At S.P. 1407 a charge of 630 lb was compared with a charge of 500 lb (Plate 14, Test 4C). The heavier charge gave better results, however, the results are not conclusive since the number of shotholes varied from 7 to 9. In production shooting, traverses H.S.1 and H.S.4 were recorded with charges of 500 lb and H.S.2 and H.S.3 with charges of 210 lbs. In both cases the heavier charges yielded much better results, however, an immediate conclusion cannot be reached because other factors were involved. See discussion below 5-3 Production Recording.

5-2-4 Geophone Comparison

Strings of eight geophones mounted in series, 20 feet apart, were used as basic element during the survey. The wave-number to be attenuated being 2 cycles/1000' that is an n.e. of 500', it was necessary to use three strings in line of 8 geophones, that is a total of 24 geophones, to reach the desired length. The strings were connected in parallel. Geophone arrays of 24 geophones in-line, with ne = 480, were used throughout the experiments as units. The only variables were the number of arrays which were laid out parallel to the line and the spacing between them. In future surveys, if the same geophone pattern length is kept, 16 geophones in-line adequately spaced to give the required length might prove to be adequate and will certainly speed up the operations. A.O.G. has been using arrays of 24 geophones in-line 12.5' apart giving an ne = 300. Results being readily available for comparison it was not thought worth while to repeat this pattern.

An experiment was devised to determine if an increase in the number of geophones would attenuate significantly the background noise. Four parallel lines 50' apart, of 24 geophones each and two parallel lines, 50' apart, of 24 geophones each were compared. Two half spreads, 12 traces each, were recorded from S.P. 1408A and 1409A, because there was not a sufficient number of geophones to record 24 traces together. The results (Plate No. 12) show a very slight improvement of the quality for 96 geophones per trace but certainly not sufficient to warrant the use of such a high number of geophones. Two reflections are better for the 48 geophone pattern. One line of 24 geophones was compared with two lines of 24 geophones in production shooting. Traverses H.S.1 and H.S.4 were recorded with 48 geophones per trace and H.S.2 and H.S.3 with 24 geophones. H.S.1 and H.S.4 yielded much better results, however, other parameters were varied so that the following conclusions may not be wholly valid. It is thought (see discussion below) that the improvement of quality with 48 geophones in two parallel lines is due to the attenuation of some of the transverse noise as well as some of the random noise.

5-2-5 Shot-hole Pattern Comparisons

In this test various in-line and diamond shot-hole patterns were compared. Some of the recordings were done with an offset of 1320' (S.P. 1408 and S.P. 1410), this technique was abandoned as explained above.

The number of holes and the spacing between holes were compared in test 4A (Plate No. 13), S.P. 1410:

- 9 holes in line 50' spacing
- 7 holes in line 50' spacing
- 5 holes in line 100' spacing
- 2 rows 100' apart of 5 holes in line 100' spacing.

The depths averaged 90' and the charges were 350 lb. The respective cut-off wave-number of these are: 2.2 cycle/1000' 2.85 cycle/1,000' 2 cycle/1,000' and 2 cycle/1,000'. The energy level is rather low and the noise fairly high. The poor quality of these results, probably due to a poor shot-point location, did not permit the evaluation of the results as expected. It appears that the longer pattern and the greater number of holes does improve slightly the quality of the data. This result is more evident on the monitor records than on the play-back records shown on the plate.

- A repeat of this test was made with a variation of hole spacing at S.P. 1408. Test 4B (Plate 13)

- 7 holes in line, 50' spacing

- 2 rows 100' apart of 5 holes in line 70' spacing.

The charge is 350 lb. Only traces 1 to 12 have the same ray path and can be used for comparison. The quality of the 7 hole record is somewhat better.

A repeat of Test 4A was made at S.P. 1407. Test 4C (Plate 13)

- 7 holes in line, 50' spacing, 500 lb charge.
- 9 holes in line, 50' spacing, 630 lb charge.

It was not always possible to vary only one parameter at a time because of the heavy field technique and the large amount of explosives used; in this test both the number of holes and the amount of explosives were varied. The 9 hole pattern yielded slightly better results.

At S.P. 1411 a comparison was made between one line and two lines of shot hole. Test 4D (Plate 13).

- 7 holes in line 70' spacing
- 2 rows 100' apart of 7 holes in line 70' spacing.

The charge is 490 lb. The 2 rows of 7 holes yielded better results. This result is much more evident in the monitor records than in the play-back records. This indicates that some transverse noise is cancelled.

Diamond shot hole patterns were compared at S.P. 1410. Test 4E (Plate 13).

- 9 holes diamond pattern 70' spacing
- 16 holes diamond pattern, 70' spacing
- 36 holes diamond pattern, 40' spacing

The charges are 360 lb, the depths are 90/ 105' and 11/15' for the 36 hole pattern. The areal pattern of 36 shallow holes gave very poor results and no more tests involving large numbers of shallow holes were attempted. The 16 hole pattern gave better results than the 9 hole pattern. The diamond pattern yielded apparently poorer results than the in-line pattern. This may be due to the fact that in this area longitudinal surface waves are more prominent than transverse waves, and are less efficiently filtered by the diamond pattern used (cut-off wave-numbers, 6.7 c/1000' and 5c/1000').

It was not always possible to shoot large hole patterns because of field conditions. On traverse H.S.1 at S.P. 1413 2/3, 13 holes in line, 35' apart, were shot to determine whether this would be a satisfactory alternative to 2 lines of 7 holes. This technique was used on traverse H.S.4 where areal patterns could not be used because of thick brush. It would seem that when heavy charges are used, it is better to distribute them into small units in a large number of shot-holes, than into large units in a small number of holes. There is less shattering of the hard sandstone and better coupling and energy transmission.

5-2-6 Conclusions of Experimental Recording

The following problems were considered in the experimental programme

5-2-6-1 Noise

Three types of noise were identified -

- Longitudinal surface noise - This noise was identified from the noise test and it was established that a wave number cut-off of 2c/1000' to 2.5 c/1,000' for the shot point and the geophone patterns would be adequate. Wave-numbers filters are periodic and have a maxima at $\frac{1}{e}, \frac{1}{2e}$, etc. ..... Since e is the spacing between the elements, there is an upper limit for e beyond which the filter is not effective. Very generally this limit is about 50'. In this particular problem n.e. should be about 450 so that n, the minimum number of holes should be 9 for an e of 50'. A 7 hole test kept e at 50' but reduced the wave-number cut-off to 2.85c/1000'; another 7 hole test kept the wave-number cut-off at 2 cycles/1000', but increased e to 70'; a 5 hole test kept the wave-number cut-off to 2 cycles/1000' but increases e to 100'. It would appear that if a 9 hole pattern with 50' spacing is to be reduced to a 7 hole pattern for economic reasons a spacing of 70' which maintains the wave-number cut-off to 2.1 c/1000' is preferable to a 50' spacing which increases it to 2.9 c/1000'. The low frequency longitudinal surface waves are attenuated by the pre-filters with a frequency cut-off of 21 c.p.s. and a slope of 24db/ octave.

- Transverse noise - This type of noise is certainly less important than the longitudinal noise and clear evidence of it was not found in the noise test. It should be successfully filtered by 2 rows of geophones 50' apart and 2 rows of shot-holes 100' apart, corresponding to the wave-numbers 9 and 18 cycles/1000'. It seems to be present on narrow ridges, in which cases, the energy is reflected at the edge of the ridges. Traverses H.S.2 and H.S.4 were both located on ridges and results were much better on H.S.4 where 2 parallel lines of geophones 50' apart were used.

- Background noise. It was mentioned above that the level of the background noise is very high. It is attributed to the wind in the brush. The only remedy for this is a high number of geophones and some ultimate attenuation. The maximum number of geophones practicable was found to be 48 per trace.

5-2-6-2 Transmission of Energy

Energy transmission in hard Hawkesbury Sandstone is poor. Heavy charges must be used, certainly no less than 350 lb and probably of the order of 500 lb for consistent results. It was determined with certainty that the charges should be placed in a hard bed and should be carefully tamped. In the area tested the optimum depth is of the order of 100'. Each time holes blew-out, there was a very important decrease of energy return. Large numbers of small charges should be used in preference to small numbers of large charges. The problem became an economic one because large numbers of holes cannot be drilled to 100'. A compromise was adopted with some success for which the depth was reduced to 60' for patterns of more than 9 holes.

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5-3 Production Recording

When the experimental programme on H.S.1 was completed production recording was carried out on the four traverses H.S.1, H.S.2, H.S.3, H.S.4 (Plates 14, 15, 16, 17, 18, 19, 20). Traverses H.S.1 and H.S.2 are located in the Kulnura area. Traverses H.S.3 and H.S.4 are located in the Grassy Hills area and were selected to test the technique developed in the Kulnura area to determine if it was usable throughout the Sydney Basin.

The experimental programme carried out on traverse H.S.1 left no doubt as to the amount of effort that should be made to obtain usable data. An all-out effort was made initially, almost to the limit of the possibilities of the party, to obtain the best possible results under present conditions. This was done in order to reach a compromise later on, between a very heavy technique yielding good data but costly and a light technique, similar to those used previously, yielding insufficient data. This compromise should be economically comparable to the "Vibroseis" and yield reasonably fair results.

Some further experimenting was done while recording the traverse, not by direct comparison because of the time factor and the amount of effort involved, but by varying the technique to suit the local problems and conditions.

5-3-1 Traverse H.S.1

Traverse H.S.1 lies on a fairly straight dirt road located in thick brush. Difficulties were encountered in laying the geophones and positioning the shot holes (Plate 14).

The best records were used to make the composite section shown on plate 17. The spread length is 1760'. The geophone pattern consists of 2 parallel lines 50' apart, each having 24 geophones in line 20' apart. The shot hole pattern is variable and is indicated on the section. The charge is about 500 lb. for each shot point and the hole depth is about 100'.

A shallow horizon, consisting of a characteristic wave train, at about 500 milliseconds, is of very good quality (Plate 17). A second horizon of fair quality, between 1,000 and 1,200 milliseconds, can be followed almost continuously. Some discontinuous deeper events can be observed.

The charges were always carefully tamped, and the record reshot whenever they blew out. The importance of this is clearly shown at S.P. 1415 for which 6 holes out of a pattern of 14 blew out and which was not reshot. Very little energy was transmitted and the quality deteriorated badly.

The poor quality of the deep reflections at SP 1404 1/3 and S.P. 1405 2/3 is due to a topographic high. Poor energy transmission was caused by thicker slow velocity shallowmaterial and by the fact that the charges were placed in softer beds, the hard sandstone bed being too deep to be reached.

5-3-2 Traverse H.S.2

Traverse H.S.2 is located on a meandering sealed road following a narrow ridge. (Plate 15). A light technique was used to afford a comparison with the "Vibroseis" method on an economic basis. It was chosen from the results obtained on H.S.1, and it is a compromise between what is thought necessary in this area and the effort that an average seismic crew can reasonably put out.

The spread length is 1760'. There is only one line of 24 geophones per trace with a 20' spacing. The shotpoint consists of 7 holes in line 70' apart. The depth is 60' and the charge 210 lb.

The quality of the section (plate 18) is not as good as for H.S.1. The shallow horizon is much poorer and not continuous. No deeper horizon can be followed over any distance. These results confirm the need for heavy charges placed in a hard bed of sandstone. Many slanted arrivals suggest that transverse noise, probably caused by the narrow ridge, is present and should be filtered by parallel lines of geophones and of shot holes as done on H.S.1.

5-3-3 Traverse H.S.3

Traverse H.S.3, in the Grassy Hills area, is located on the Windsor to Singleton road (Plate 16) which is a straight sealed road of easy access. In this location, which is on an alluvial plain the Hawkesbury Sandstone is much softer and drilling was fairly easy. Again a light technique was used to make a comparison with the "Vibroseis"method on an economic basis. The spread length was 1760'. Each trace consisted of one line of 24 geophones 20' apart, and the shot point pattern consisted of 7 holes in line 70' apart. The total charge is 210 lb. at a depth of 60'.

This technique yielded much better results (plate 19) than for H.S.2. This is attributed to the fact that the Hawkesbury Sandstone is not as hard in that particular area and energy transmission is better. This technique, however, is not powerful enough to give consistently good results, since there is a definite degradation of quality to the north of the traverse.

5-3-4 Traverse H.S.4

Traverse H.S.4, in the Grassy Hills area, is located on a meandering track following a ridge which is narrowing to the east (plate 16.) The track is of a fairly easy access, however, the topography is rugged and the brush fairly thick and of difficult access for shot-hole or geophone patterns. Since the difficulties inherent to this traverse (Narrow ridge, difficult access) are fairly typical of the Sydney Basin problems, it was decided that the heavy technique developed on H.S.1 should be adapted here to meet the local conditions.

The technique used is as follows: spread length 1760'. Two parallel lines 50' apart of 24 geophones in line 20' apart. Because of the difficult conditions, the geophones were hard to lay down and the patterns were somewhat irregular. It was impossible to have a shot hole pattern of two parallel lines of seven holes each, however it was thought advisable to keep a high number of holes, so 13 holes in line, 35' apart were used. The total charge was 490 lb. at a depth of 50' to 60'.

The section (plate 20) shows continuous horizons at 500, 800 and 1600 milliseconds. To the west the results are quite good, but to the east from S.P.1704 on, there is a degradation of the quality corresponding to a narrowing of the ridge.

5-3-5 Conclusions to Production Recording

The best results obtained are on traverse H.S.1 for which a heavy technique was used. A light technique used on traverse H.S.2 yielded extremely poor results. The differences are: only one line of holes and of geophones, and consequently no filtering of the transverse noise; 210 lb instead of 500 lb. of explosive at a depth of 60' instead of 100'. In as much as the deep data on H.S.1 is not continuous, it seems that the technique used cannot be reduced significantly without serious loss of quality. A similar technique should be used in areas such as this one, where the Hawkesbury Sandstone is extremely hard, if usable data are desired.

The same light technique used on H.S.2 was used on H.S.3 and gave fair results, probably because the characteristics of the sandstone have changed, in particular it is much softer, and because H.S.2 is located on a ridge while H.S.3 is in a plain where there is less transverse noise. Degradation of quality to the north of H.S.3 suggests that this technique is too light for consistently good results in easy areas such as this one.

The technique used on H.S.1 was modified on H.S.4 to suit the rugged ridge conditions that is, 13 shot holes in line were used instead of two parallel lines of 7 shot holes each. It was impossible to position the drills in the brush and the shot point pattern had to be laid on the track. The results are fair but the degradation of quality where the ridge narrows is very probably due to a lack of filtering of transverse noise by the shot point pattern.

6. Conclusions

This experimental survey has defined and studied the major seismic problems of the Sydney Basin. Solutions for them are set forward. Some results of the testing are ambiguous and the relative merits of two similar techniques have not always been determined, however, some important conclusions fundamental to the techniques to be used have been reached. An optimum method has not been found as it is only with much experience of the basin that the best use of the parameters discussed in this report can be determined. In particular, on narrow ridges, where conflicting conditions exist, that is where large shothole and geophone patterns are necessary but cannot be laid because of rugged topography, the best compromise is yet to be determined.

The main conclusions may be summarised thus:

- The nature of the Hawkesbury Sandstone is variable throughout the Sydney Basin and preliminary testing is necessary before adopting a particular technique.

- Dynamite charges should be heavy. In this survey no consistently good results have been obtained in difficult conditions with less than 500 lb. This amount may be reduced if an improved technique is found. Where easier conditions exist, such as H.S.3 the charge may be reduced to about 250 lb.

- Energy transmission is a major problem and the explosions should be done under controlled conditions. The optimum depth must be used and the charges must be carefully tamped to avoid upward dissipation of energy. Heavy unit charges must be avoided to prevent too much loss of energy in shock waves and heavy fracturing of the formation. The maximum unit charge has not been determined but it is thought to be about 35 lb. In the Kulnura area the Hawkesbury Sandstone is extremely hard and problems of energy transmission associated with a very hard medium have to be dealt with. It was found that energy transmission was best when the explosive was placed in a hard bed and poor when it was placed in soft material above the hard formtion. In the Grassy Hills area the Hawkesbury Sandstone is not as hard, there is no contrast of softer formation above a harder formation, and the energy transmission is much better even though the charge is placed in relatively soft material.

.../14

- Long shot-hole and geophone patterns should be used to cancel longitudinal noise. The spatial filter must be designed for a wave-number cut-off of 2 to 2.5 cycles/1.000'. This filter is very strong and care must be taken not to filter any signal where the beds are dipping or the traverse is on a slope. This problem was not encountered during the testing since no dipping of the formations existed on the site. The use of a pre-filter is advisable to avoid saturation of the early stages of amplification by the high amplitude low-frequency noise.

- Transverse noise may be present and parallel longitudinal lines were helpful in cancelling it. Shot-hole diamond patterns were found to be inefficient.

- Background noise, probably due to wind in the brush, has a high level and should be filtered by a large number of geophones. For most experiments 48 geophones were used, but 32 in two parallel lines of 16 might prove to be adequate.

- A 50 c.p.s. notch filter is recommended to eliminate pick-up from high-voltage lines which are numerous in the area.

Appendix 1

Staff and Equipment

1. Staff

Party Leader	J. S. RAITT
Geophysicist	B. F. JONES
Observer	G. S. JENNINGS
Clerk	J. G. TERPSTRA
Shooter	R. D. CHERRY
Driller Grade 2	J. KEUNEN
Driller Grade 1	W. WHITBURN
	L. A. KEAST
Mechanic	E. McINTOSH
Surveyor	N. PESAVENTO (Dept. of Interior)

2. Equipment

Amplifiers	- Texas Instruments 7000B
Oscillograph	- S.I.E. V.T.6
Magnetic Recorder	- S.I.E. F.M. PMR20 Electro Tech. DS7/700
Programmed Gain Central Unit	- S.I.E. G.C.U/3E.C.
Pre-Filters	- C.G.G.
Geophones	- Halls-Sears HS-J (1312 in groups of 8)
- Energy [illegible]	
Cables	- Vector 1800 feet and 1320 feet
Drills	- 2 Mayhew 1000 1 Carey 1 Failing (under contract)

Appendix 2

Operational data

Sedimentary Basin	Sydney
Area	Gosford N.S.W.
Shooting commenced	13th Sept. 1965
Shooting ceased	19th Nov. 1965

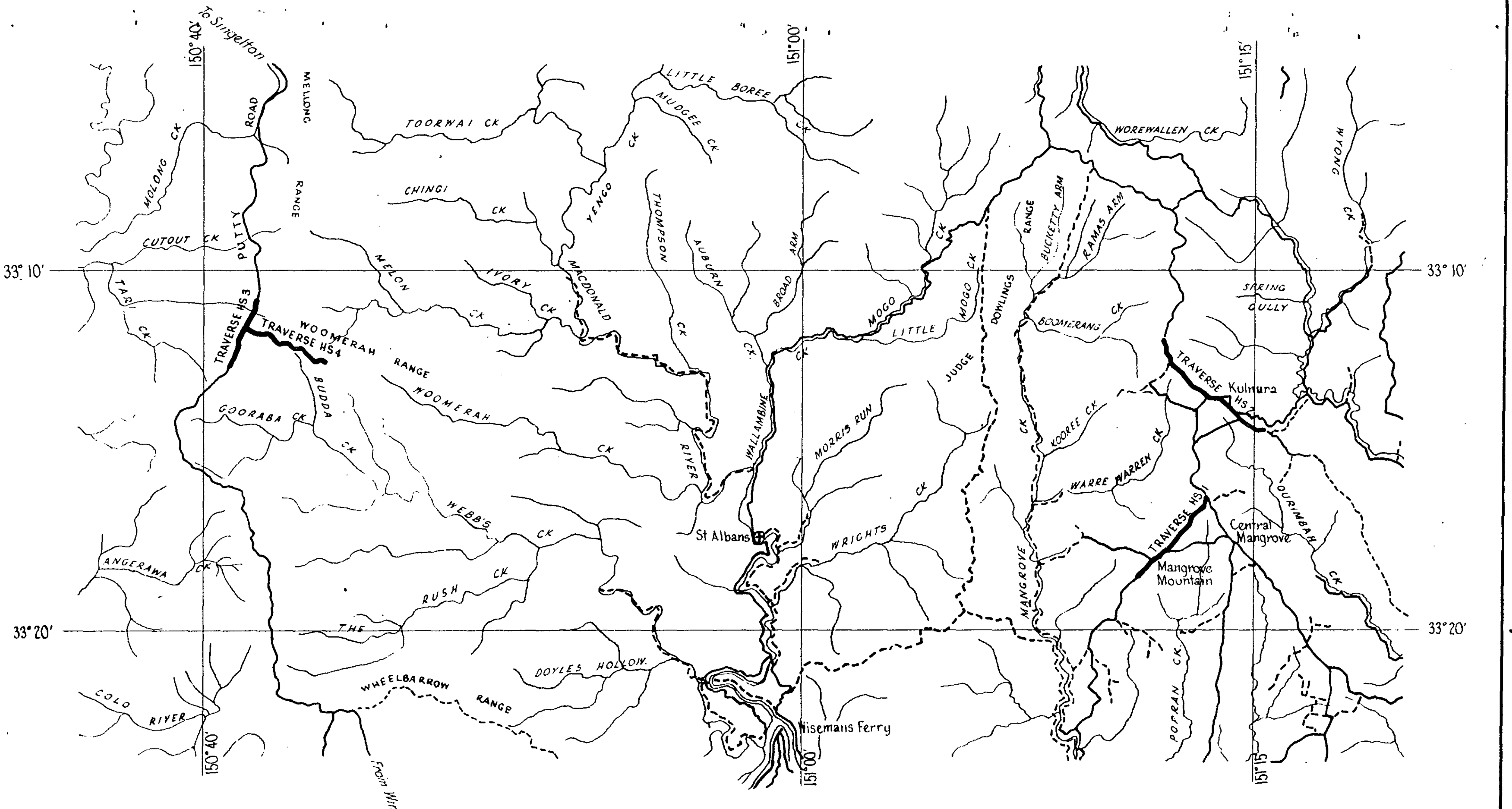
	H.S.1	H.S.2	H.S.3	H.S.4
Datum level for correction	900' A.S.L.	1000' A.S.L.	1,100' A.S.L.	1,100' A.S.L.
Weathering velocity	3,300'/sec	3,300'/sec	3,000'/sec	3,000'/sec
Sub-weathering velocity	8,300'/sec	8,300'/sec	10,000'/sec	10,000'/sec

Static correction method	Uphole times and interpolation
Velocity function	V = 12,000'/sec
Derivation of velocity function	t - Δt analysis

	H.S.1	H.S.2	H.S.3	H.S.4
Total footage drilled	24,905'	7,050'	2,220'	7,088'
Total number of holes drilled	297	106	37	110
Total number of field hours	743½	113½	47	76½
Total number of drilling hours	417	74	18	39
Average penetration rate (in feet per hour)				
1. Mayhew	59.8	101	123.3	181.7
2. Failing	59.5	72.7	-	-
Total number of field hours	285½	69½	20	59
Total number of recording hours				
1. Experimental	123¼	22½	2	13½
2. Production	62¾	35	7½	25
Total number of profiles				
1. Experimental	94	19	2	14
2. Production	22	24	10	16

.../2

	H.S.1	H.S.2	H.S.3	H.S.4
Total explosive used				
1. 3 inch	15,277½	3,240	1,100	5,390
2. 2¼ inch	1,865	40	-	80
Total detonator used				
1. 100 feet	492	103	38	128
2. 30 feet	8	-	-	-
Total miles traversed	3.35	4.35	1.93	3.16



LOCALITY PLAN

SEISMIC TRAVERSES HS1. 2. 3 & 4.

SYDNEY BASIN

Reference SYDNEY 1:250,000 Military Survey

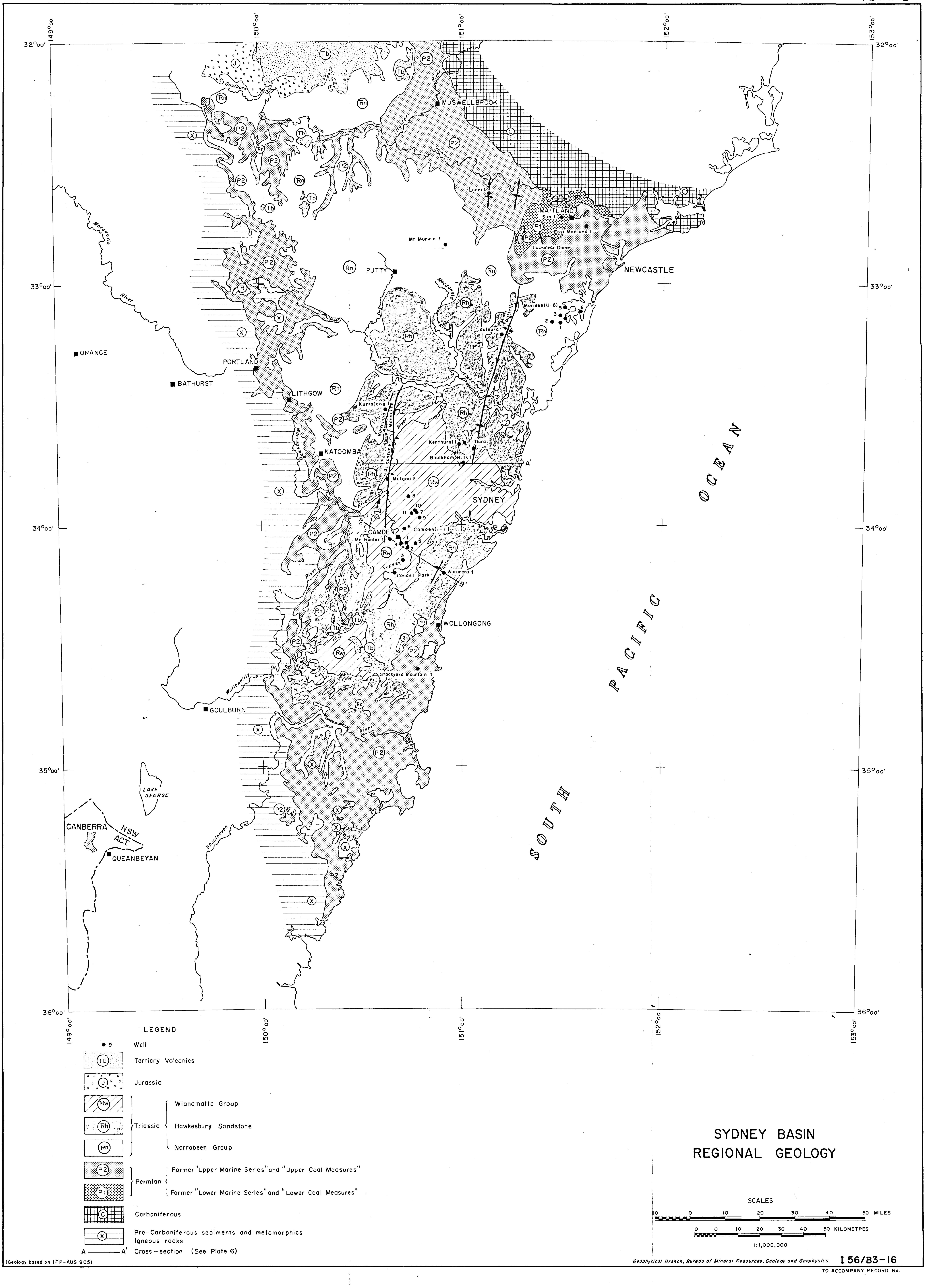
I56/B3-31

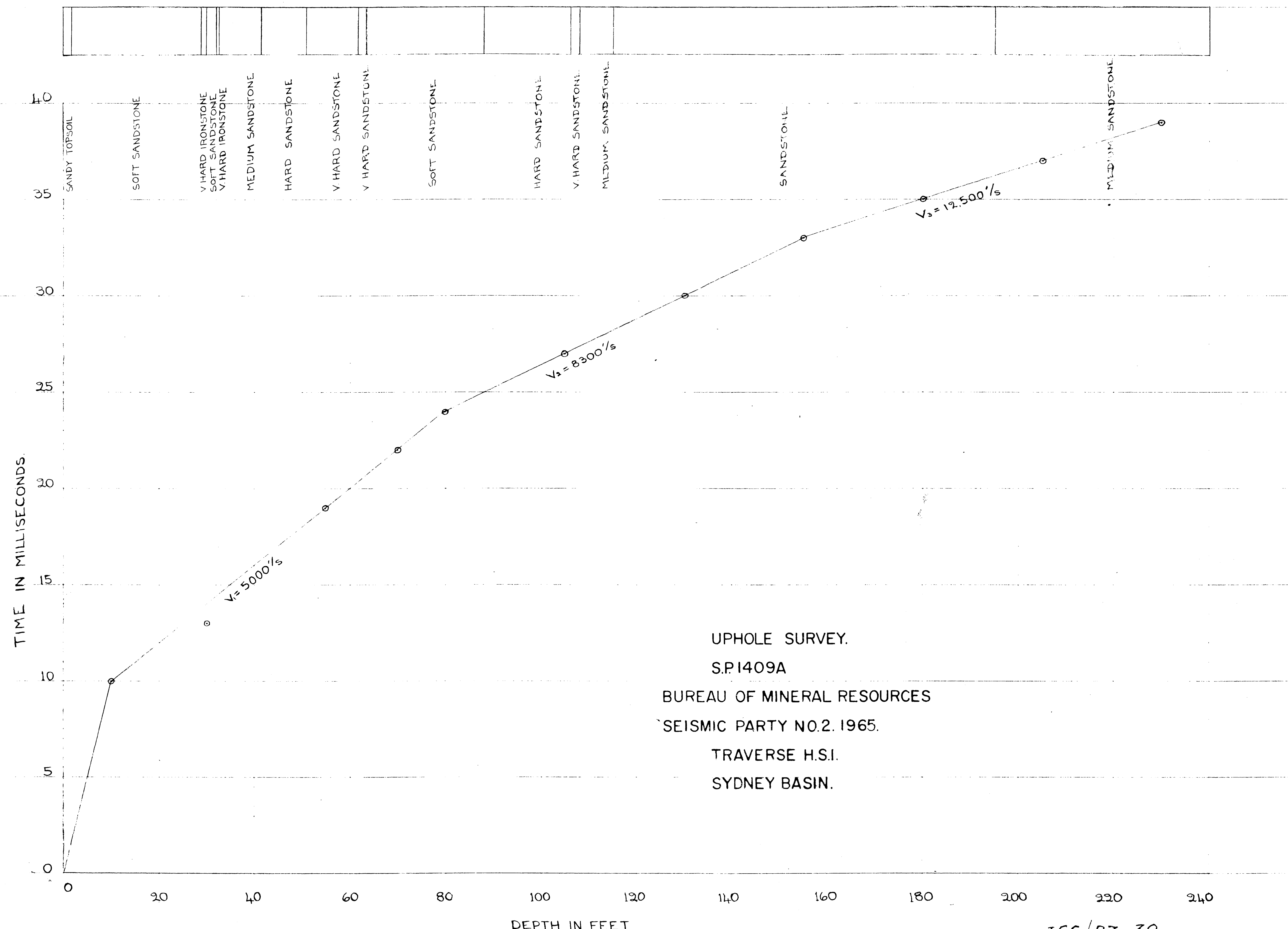
PLATE 1

BMR 107 sh 1

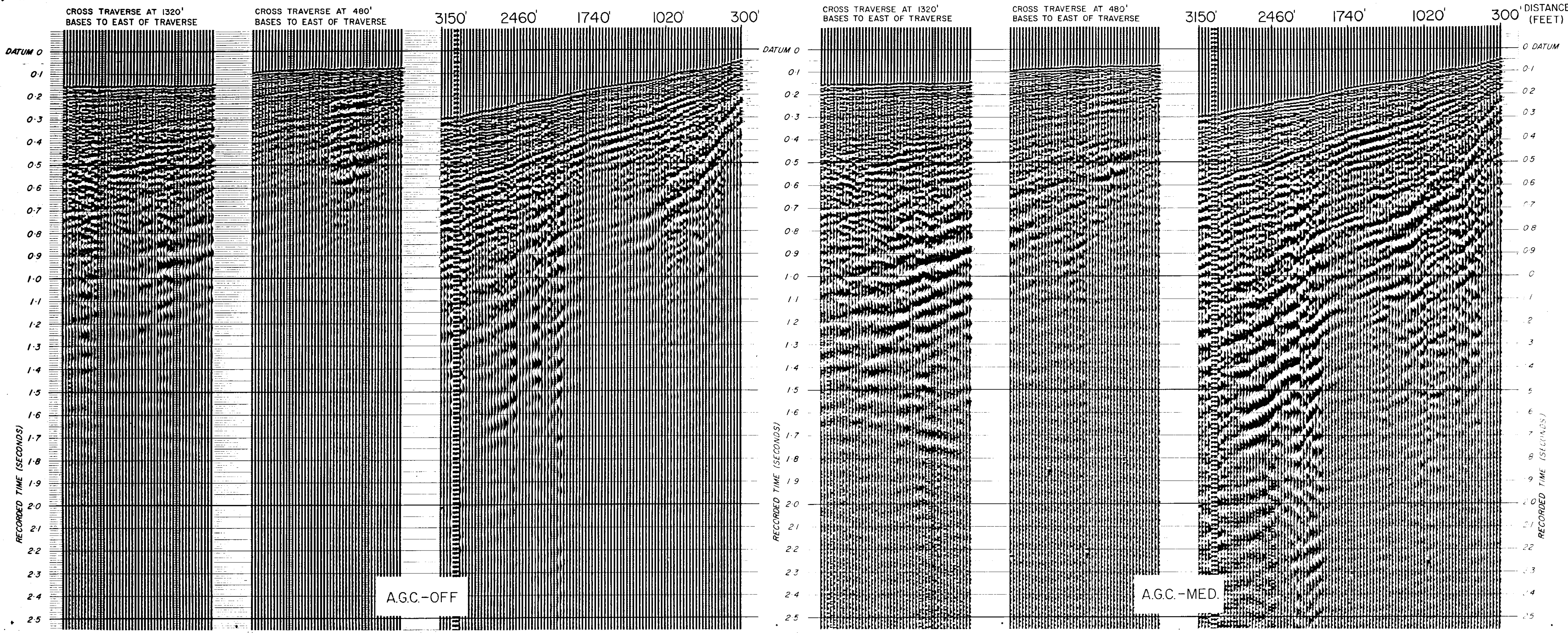
Prepared by the Survey Branch Dept of the Interior Canberra 1965

PLATE 2


SYDNEY BASIN
REGIONAL GEOLOGY
LEGEND
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
Cross-section (See Plate 6)
SCALES
1:1,000,000
MILES
KILOMETRES
SOUTH PACIFIC OCEAN
MUSWELLBROOK
MAITLAND
NEWCASTLE
PUTTY
ORANGE
PORTLAND
BATHURST
LITHGOW
KATOOMBA
SYDNEY
CAMDEN
WOLLONGONG
GOULBURN
CANBERRA
QUEANBEYAN
LAKE GEORGE
NSW
ACT
Mt Murwin 1
Loder 1
East Maitland 1
Lochinvar Dome
Morisset (1-6)
Kulnura 1
Kurrajong 1
Kenthurst 1
Dural 1
Baulkham Hills 1
Mulgoa 2
Camden (1-11)
Mt Hunter 1
Condell Park 1
Woronora 1
Stockyard Mountain 1
(Geology based on IFP-AUS 905)
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics
I 56/B3-16
TO ACCOMPANY RECORD No.


SANDY TOPSOIL
SOFT SANDSTONE
V.HARD IRONSTONE
SOFT SANDSTONE
V.HARD IRONSTONE
MEDIUM SANDSTONE
HARD SANDSTONE
V.HARD SANDSTONE
V.HARD SANDSTONE
SOFT SANDSTONE
HARD SANDSTONE
V.HARD SANDSTONE
MEDIUM SANDSTONE
SANDSTONE
MEDIUM SANDSTONE
$V_1 = 5000'/s$
$V_2 = 8300'/s$
$V_3 = 12{,}500'/s$
TIME IN MILLISECONDS.
DEPTH IN FEET.
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100
120
140
160
180
200
220
240
UPHOLE SURVEY.
S.P. 1409A
BUREAU OF MINERAL RESOURCES
SEISMIC PARTY NO.2. 1965.
TRAVERSE H.S.I.
SYDNEY BASIN.

156/B3-38



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: KO-K120

A.G.C.: OFF

Gain Initial: } Various
Final: }

Geophones: EVS 8B - 4·5c/s

Geophone pattern:
4/trace bunched

Shot-hole pattern:

PLAYBACK INFORMATION

Filters: 1/16 - 1/135

A.G.C.: Med. and Off

	with A.G.C.	w/out A.G.C.
Gain Initial	-40	-40
Final	-20	-40
Trip delay	0 - ·2sec	0
Compositing	Nil	

VELOCITY INFORMATION

HORIZONTAL SCALE

Longitudinal bases - 30' between traces

Transverse bases - 12·5' between traces

EXPERIMENTAL SEISMIC SURVEY
FOR COMPARISON WITH
VIBROSEIS SURVEY, 1965
SYDNEY BASIN

TRAVERSE HS1

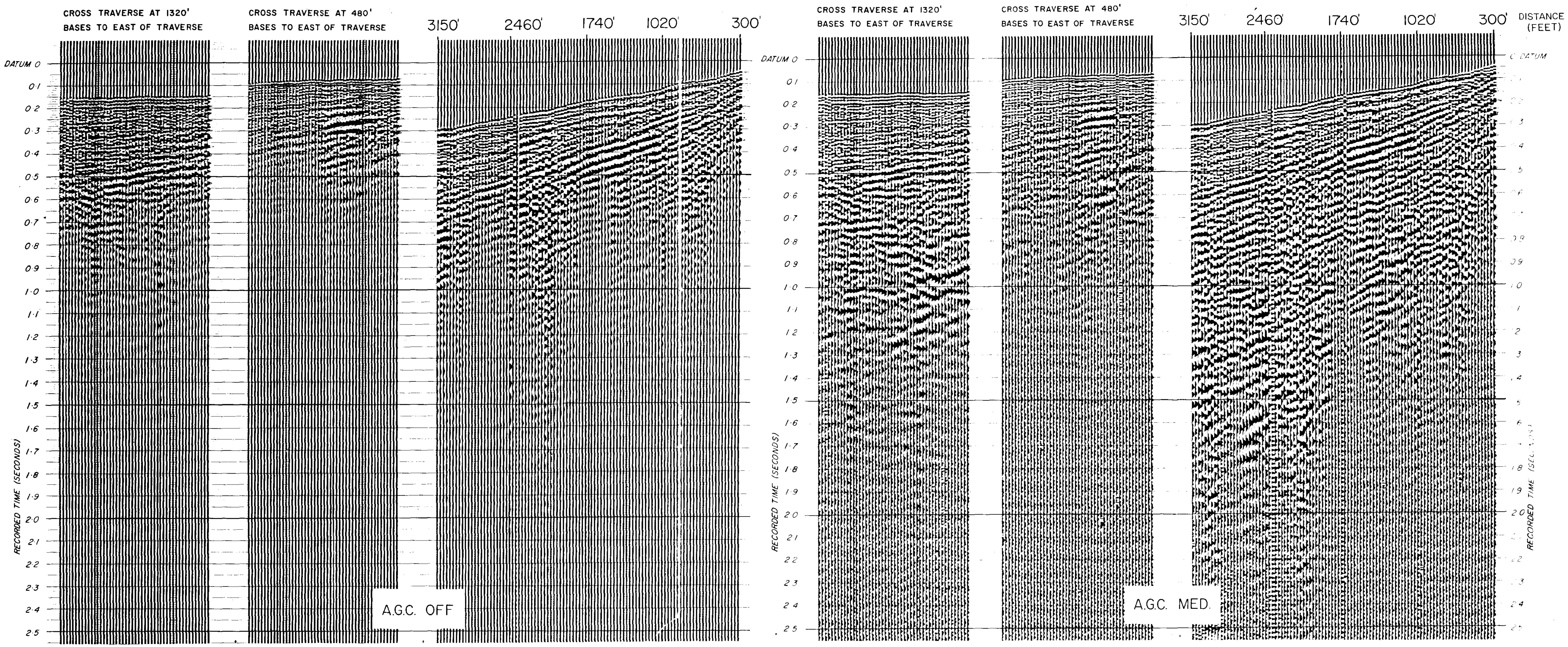
NOISE ANALYSIS 1409B

RECORDED BY: *Seismic Party No. 2*

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

I56/B3-23

PLATE 5



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: PREFILTERS 18c/s, 12db/o KO-K120

A.G.C.: OFF

Gain Initial / *Final*: Various

Geophones: HSJ-14c/s

Geophone pattern: 8/trace bunched

Shot-hole pattern:

PLAYBACK INFORMATION

Filters: 1/16-1/135

A.G.C.: Med. and Off

	with A.G.C.	w/out A.G.C.
Gain Initial	-40	-40
Final	-20	-40
Trip delay	0-·2sec	0
Compositing	Nil	

VELOCITY INFORMATION

HORIZONTAL SCALE

Longitudinal bases - 30' between traces

Transverse bases - 12·5' between traces

EXPERIMENTAL SEISMIC SURVEY
FOR COMPARISON WITH
VIBROSEIS SURVEY, 1965
SYDNEY BASIN

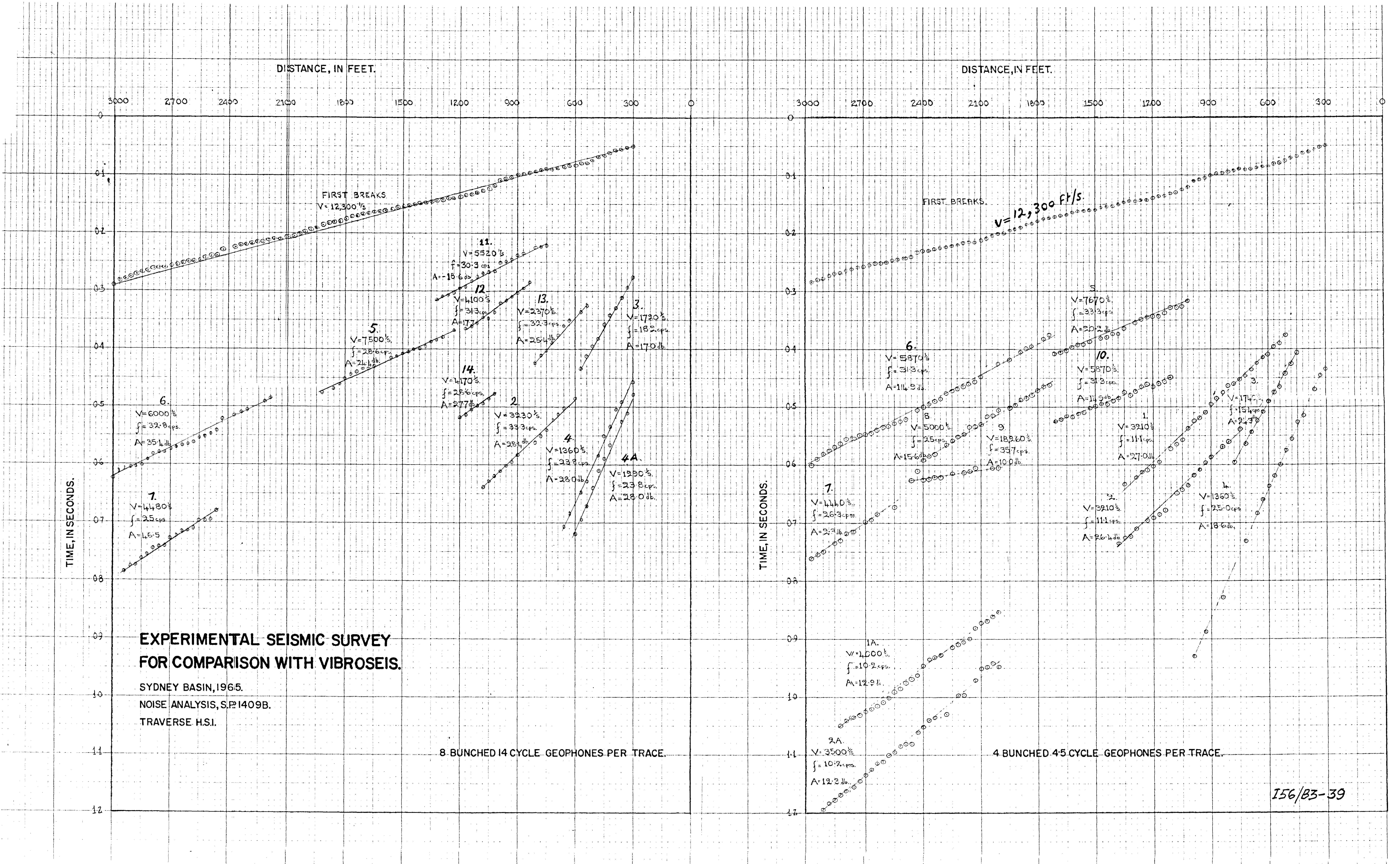
TRAVERSE HSI

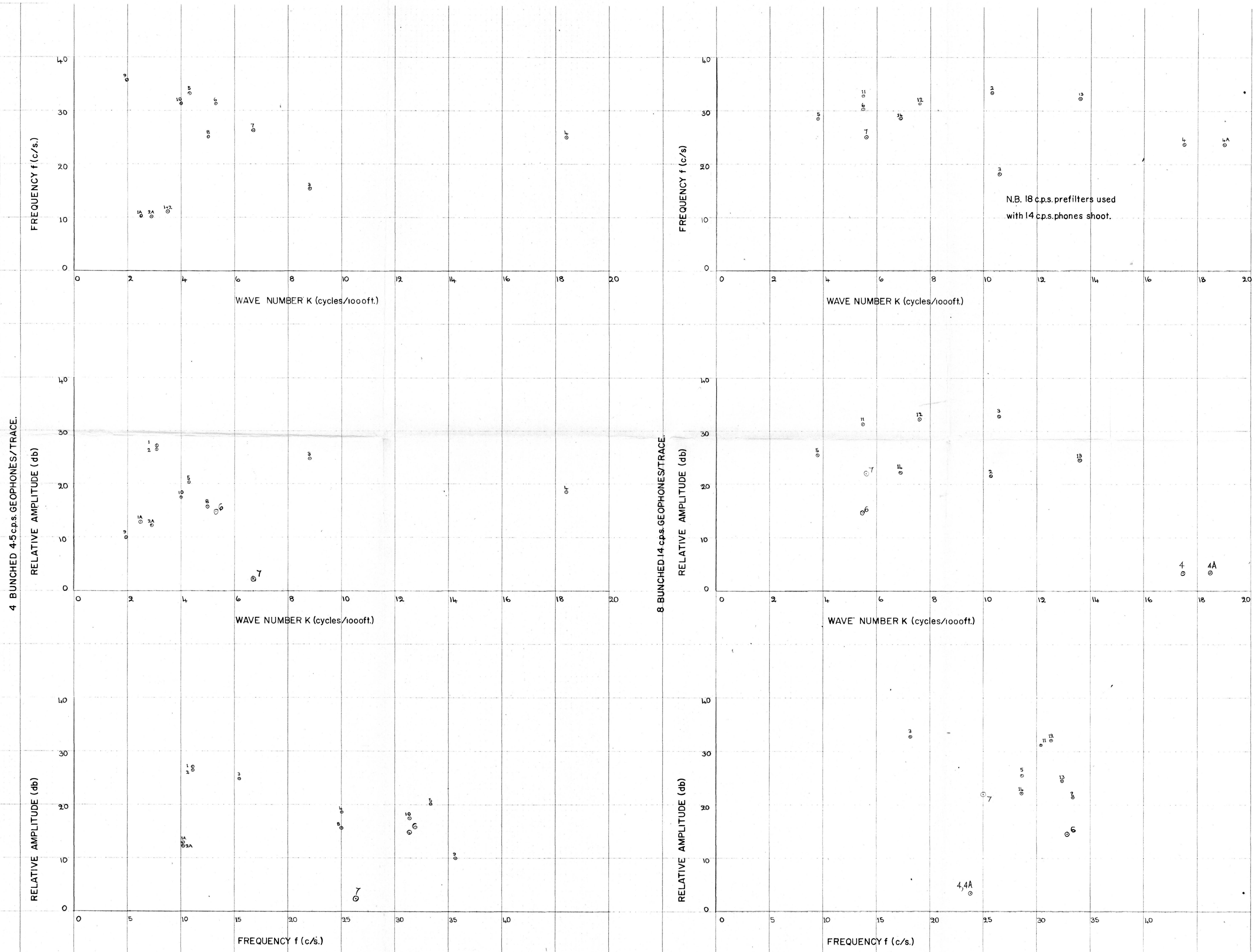
NOISE ANALYSIS 1409B

RECORDED BY: *Seismic Party No. 2*

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

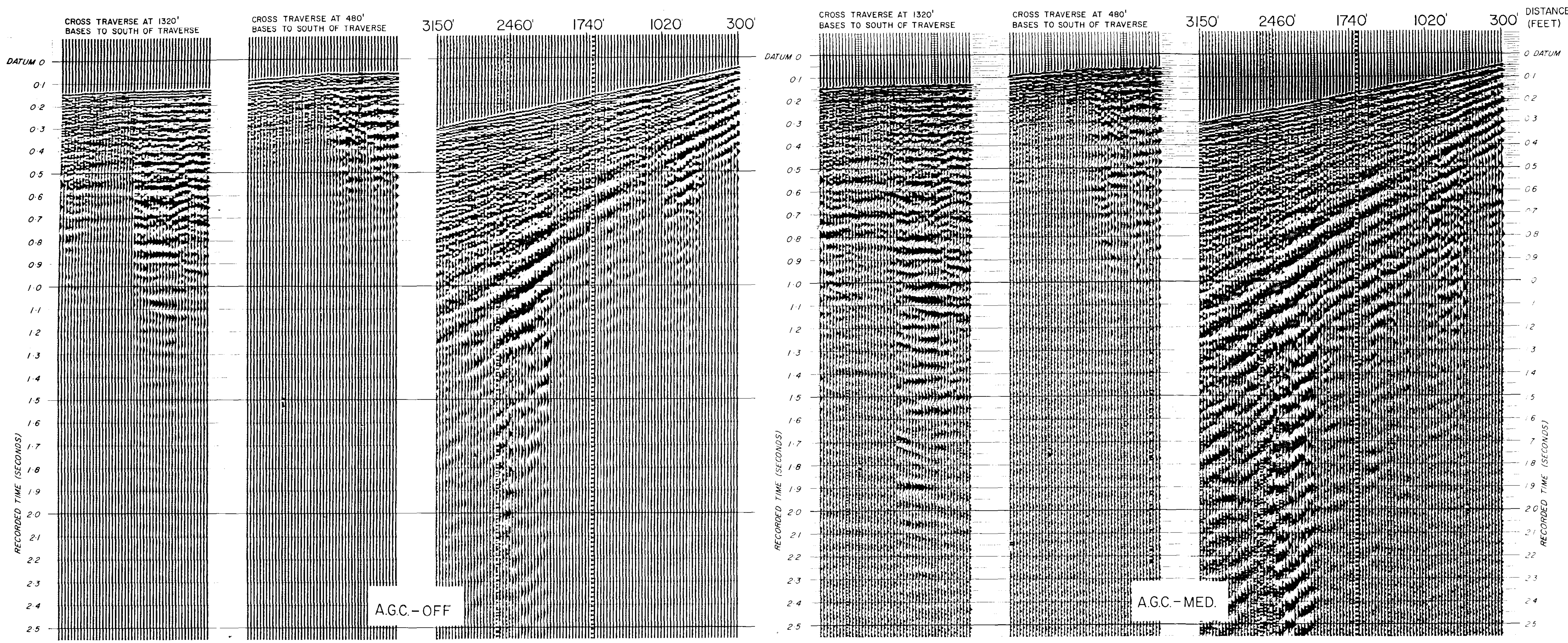
I56/B3-22


EXPERIMENTAL SEISMIC SURVEY
FOR COMPARISON WITH VIBROSEIS.
SYDNEY BASIN, 1965.
NOISE ANALYSIS, S.P. 1409B.
TRAVERSE H.S.I.
DISTANCE, IN FEET.
TIME, IN SECONDS.
FIRST BREAKS.
V=12,300 ft/s.
8 BUNCHED 14 CYCLE GEOPHONES PER TRACE.
4 BUNCHED 4·5 CYCLE GEOPHONES PER TRACE.
I56/B3-39



NOISE ANALYSIS S.P.1409B.
TRAVERSE HSI.
GOSFORD, N.S.W.
SEISMIC PARTY NO.2.1965.
BUREAU OF MINERAL RESOURCES.

I56/83-37



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: KO-K120

A.G.C.: OFF

Gain Initial: / *Final:* } Various

Geophones: EVS 8B – 4·5 c/s

Geophone pattern: 4/trace bunched

Shot-hole pattern: —

PLAYBACK INFORMATION

Filters: 1/16 – 1/135

A.G.C.: Med. and Off

	with A.G.C.	w/out A.G.C.
Gain Initial:	-40	-40
Final:	-20	-40
Trip delay:	0 – ·2 sec	0

Compositing: Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

Longitudinal bases – 30' between traces

Transverse bases – 12·5' between traces

EXPERIMENTAL SEISMIC SURVEY
FOR COMPARISON WITH
VIBROSEIS SURVEY, 1965
SYDNEY BASIN

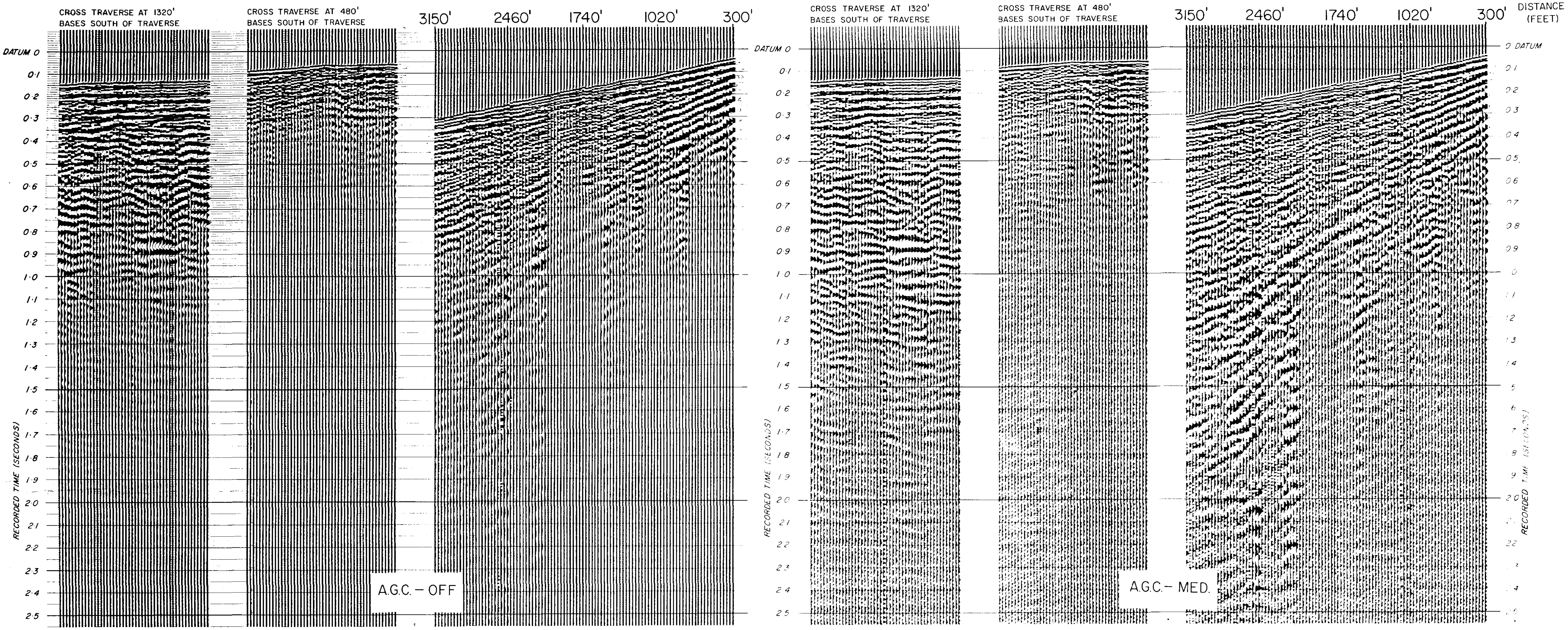
TRAVERSE HS 2

NOISE ANALYSIS 1487B

RECORDED BY: *Seismic Party No. 2*

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

I56/B3-20



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

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

A.G.C.: OFF

Gain Initial / *Final*: Various

Geophones: HSJ-14c/s

Geophone pattern: 8/trace bunched

Shot-hole pattern: —

PLAYBACK INFORMATION

Filters 1/16 - 1/135

A.G.C.: Med. and Off

	with A.G.C.	w/out A.G.C.
Gain Initial	-40	-40
Final	-20	-40
Trip delay	0 - ·2 sec	0
Compositing	Nil	

VELOCITY INFORMATION

—

HORIZONTAL SCALE

Longitudinal bases – 30' between traces

Transverse bases – 12·5' between traces

EXPERIMENTAL SEISMIC SURVEY
FOR COMPARISON WITH
VIBROSEIS SURVEY, 1965
SYDNEY BASIN

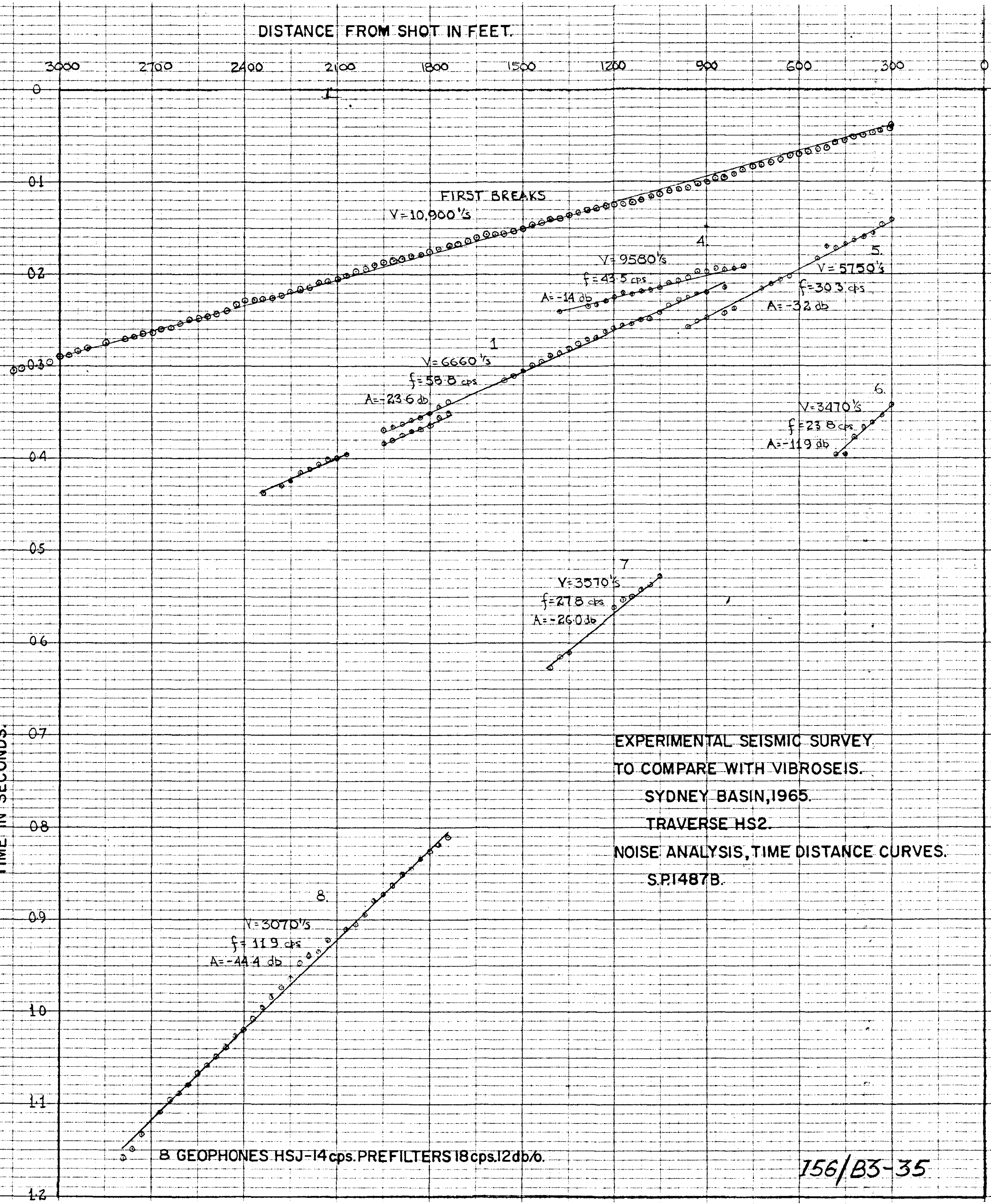
TRAVERSE HS 2

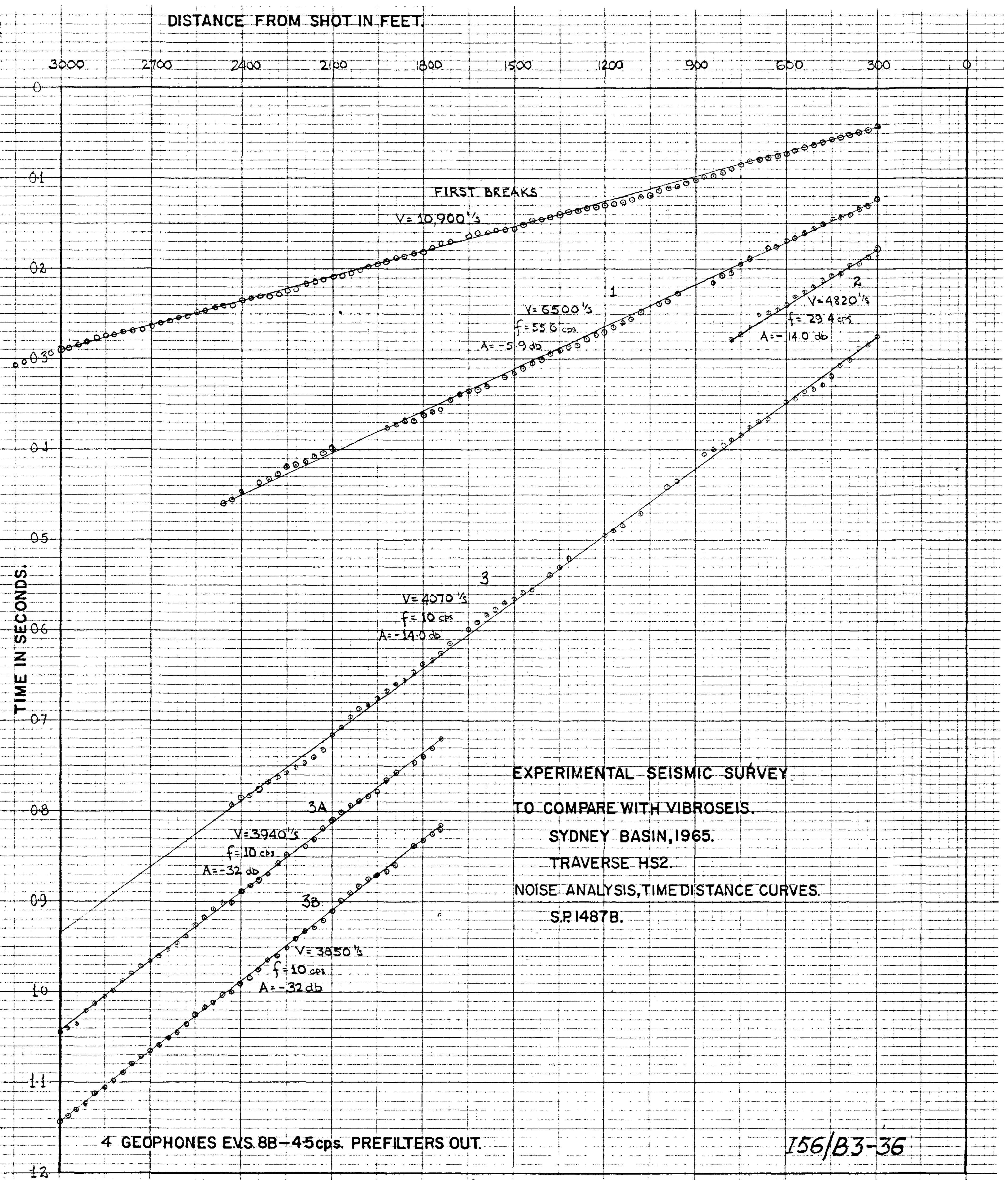
NOISE ANALYSIS 1487B

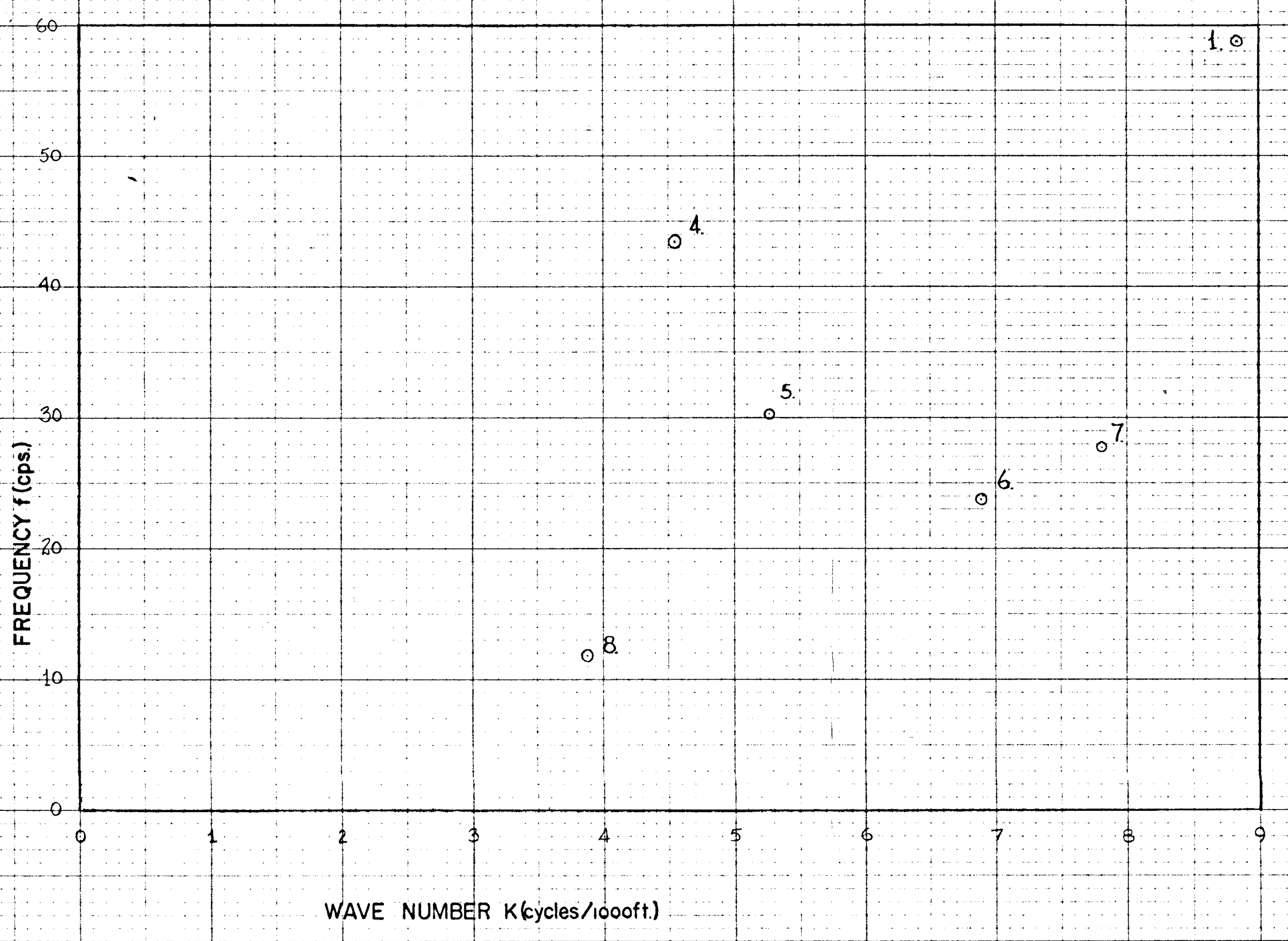
RECORDED BY: Seismic Party No 2

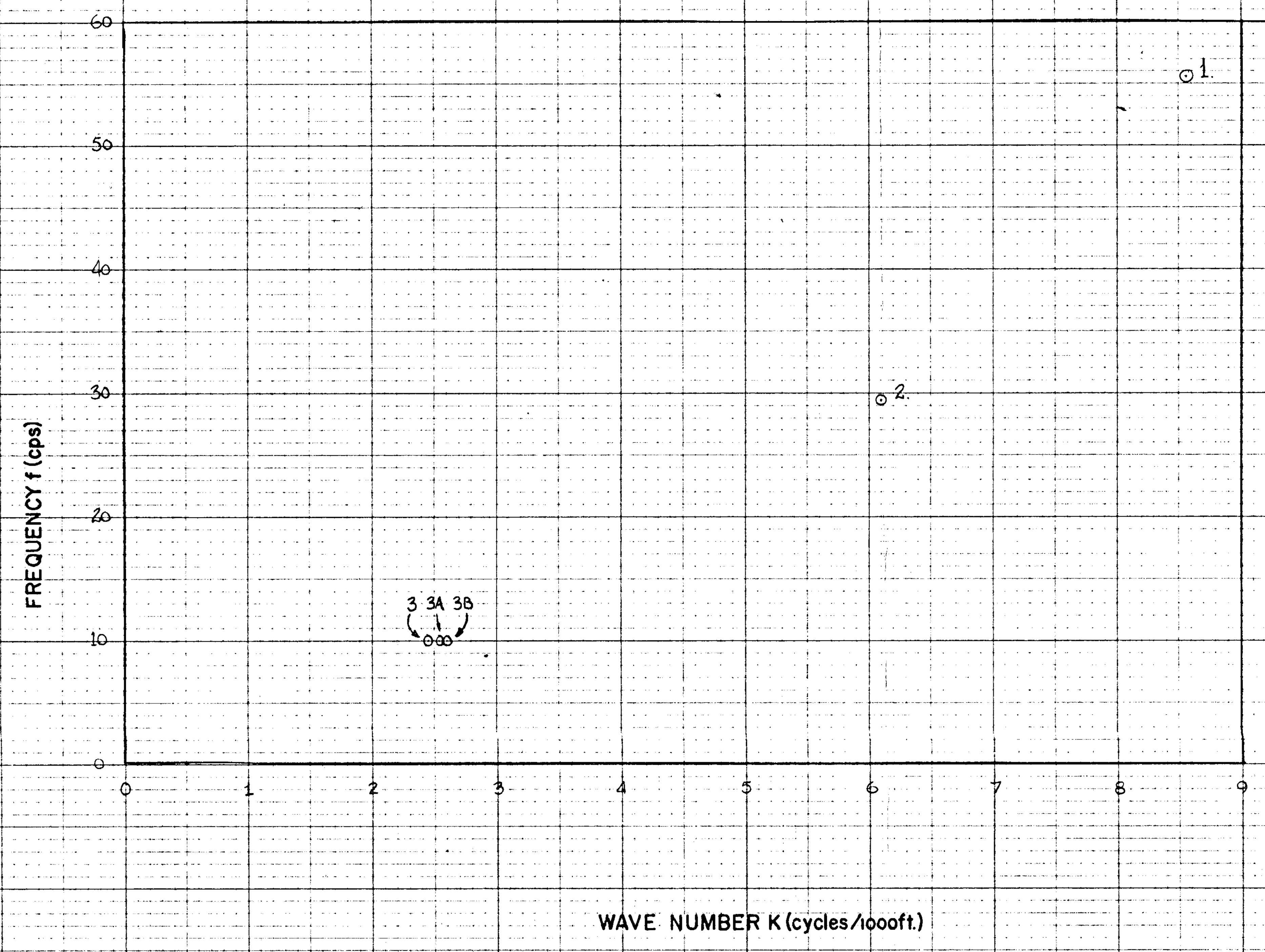
SECTION by: Bureau of Mineral Resources Playback Centre SIE MS 42

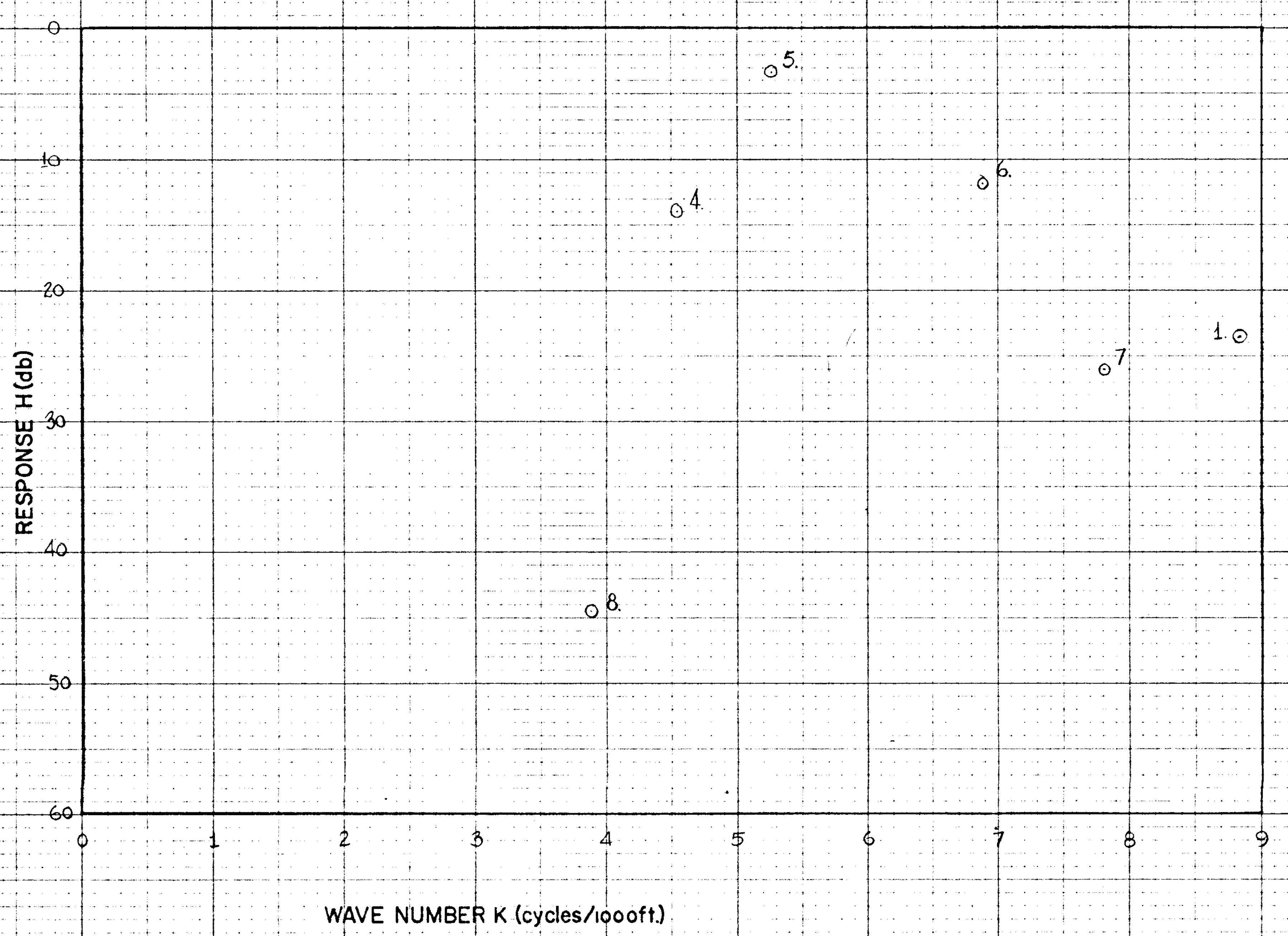
I56/B3-21

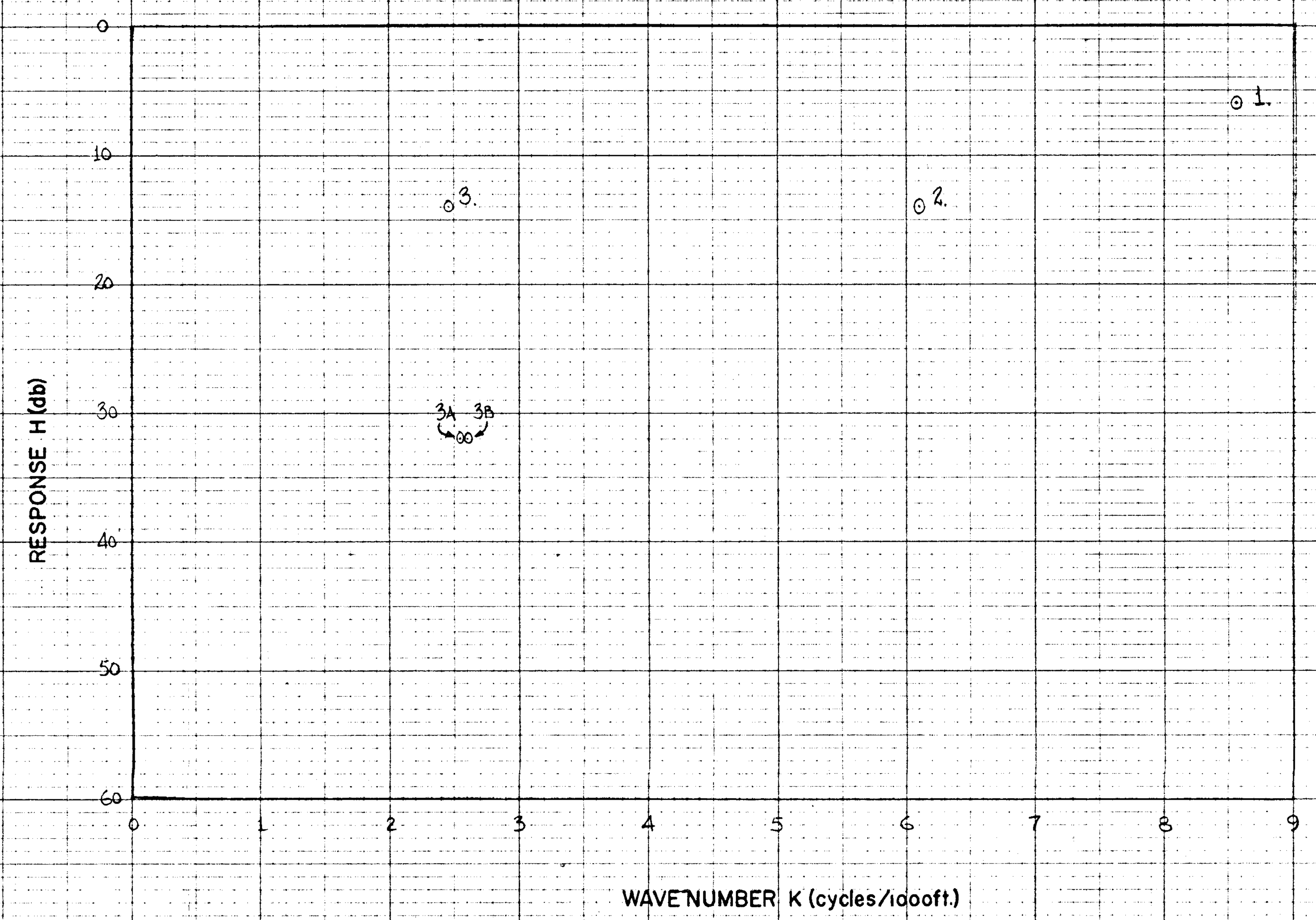

DISTANCE FROM SHOT IN FEET.
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
TIME IN SECONDS.
0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
1·1
1·2
FIRST BREAKS
V=10,900'/s
4.
V=9580'/s
f=43·5 cps
A=-14 db
5.
V=5750'/s
f=30·3 cps
A=-32 db
1
V=6660'/s
f=58·8 cps
A=-23·6 db
6.
V=3470'/s
f=23·8 cps
A=-11·9 db
7
V=3570'/s
f=27·8 cps
A=-26·0 db
8.
V=3070'/s
f=11·9 cps
A=-44·4 db
EXPERIMENTAL SEISMIC SURVEY
TO COMPARE WITH VIBROSEIS.
SYDNEY BASIN, 1965.
TRAVERSE HS2.
NOISE ANALYSIS, TIME DISTANCE CURVES.
S.P.1487B.
8 GEOPHONES HSJ-14 cps. PREFILTERS 18 cps. 12 db/o.
156/B3-35


DISTANCE FROM SHOT IN FEET.
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
TIME IN SECONDS.
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
FIRST BREAKS
V=10,900'/s
1
V=6500'/s
f=55·6 cps
A=-5·9 db
2
V=4820'/s
f=23·4 cps
A=-14·0 db
3
V=4070'/s
f=10 cps
A=-14·0 db
3A
V=3940'/s
f=10 cps
A=-32 db
3B
V=3850'/s
f=10 cps
A=-32 db
EXPERIMENTAL SEISMIC SURVEY
TO COMPARE WITH VIBROSEIS.
SYDNEY BASIN, 1965.
TRAVERSE HS2.
NOISE ANALYSIS, TIME DISTANCE CURVES.
S.P.1487B.
4 GEOPHONES E.V.S. 8B-4·5 cps. PREFILTERS OUT.
156/B3-36



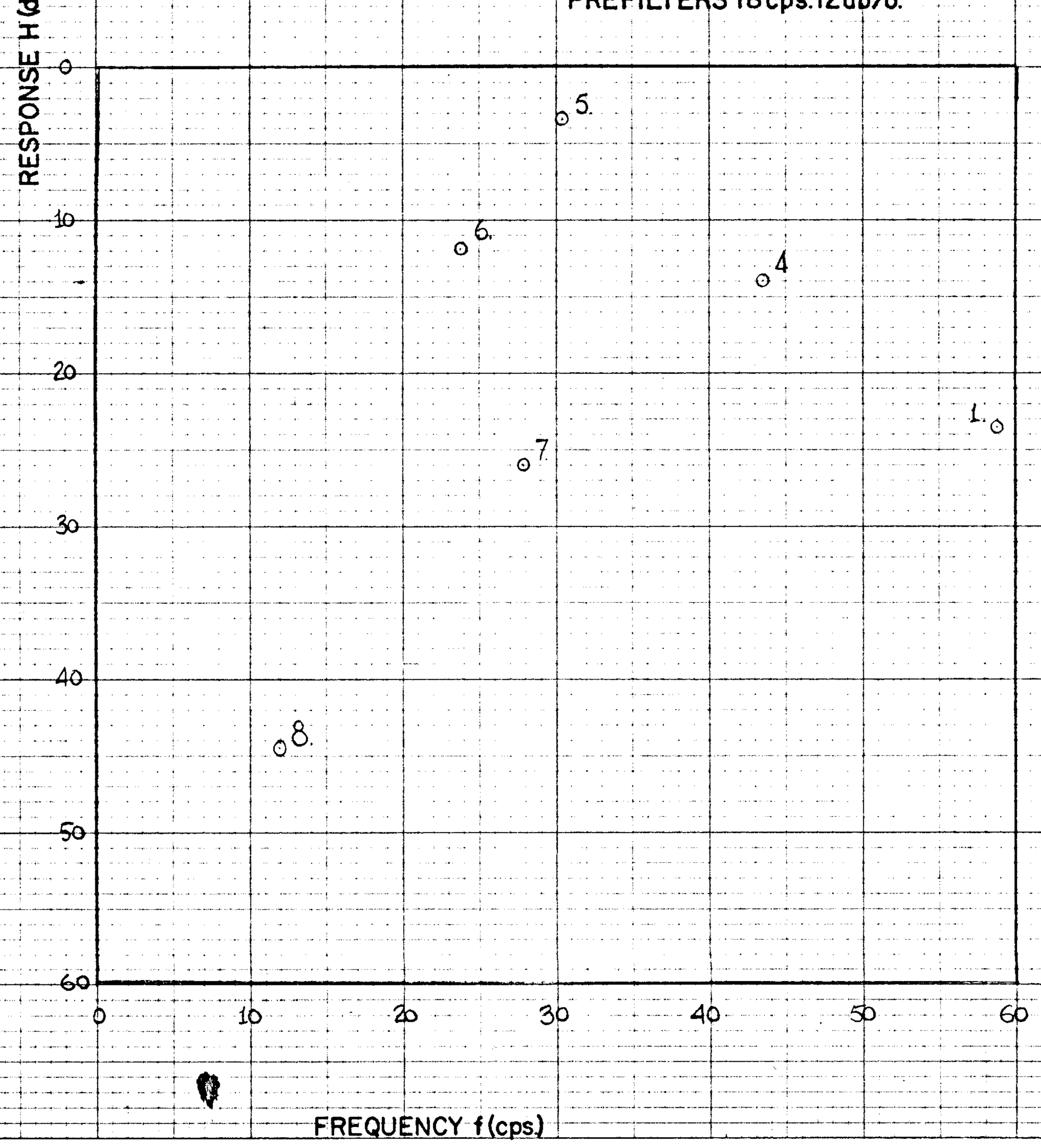






GEOPHONES HSJ–14cps.
PREFILTERS 18cps.12db/o.

GEOPHONES EVS.8B–4·5cps.
PREFILTERS OUT.

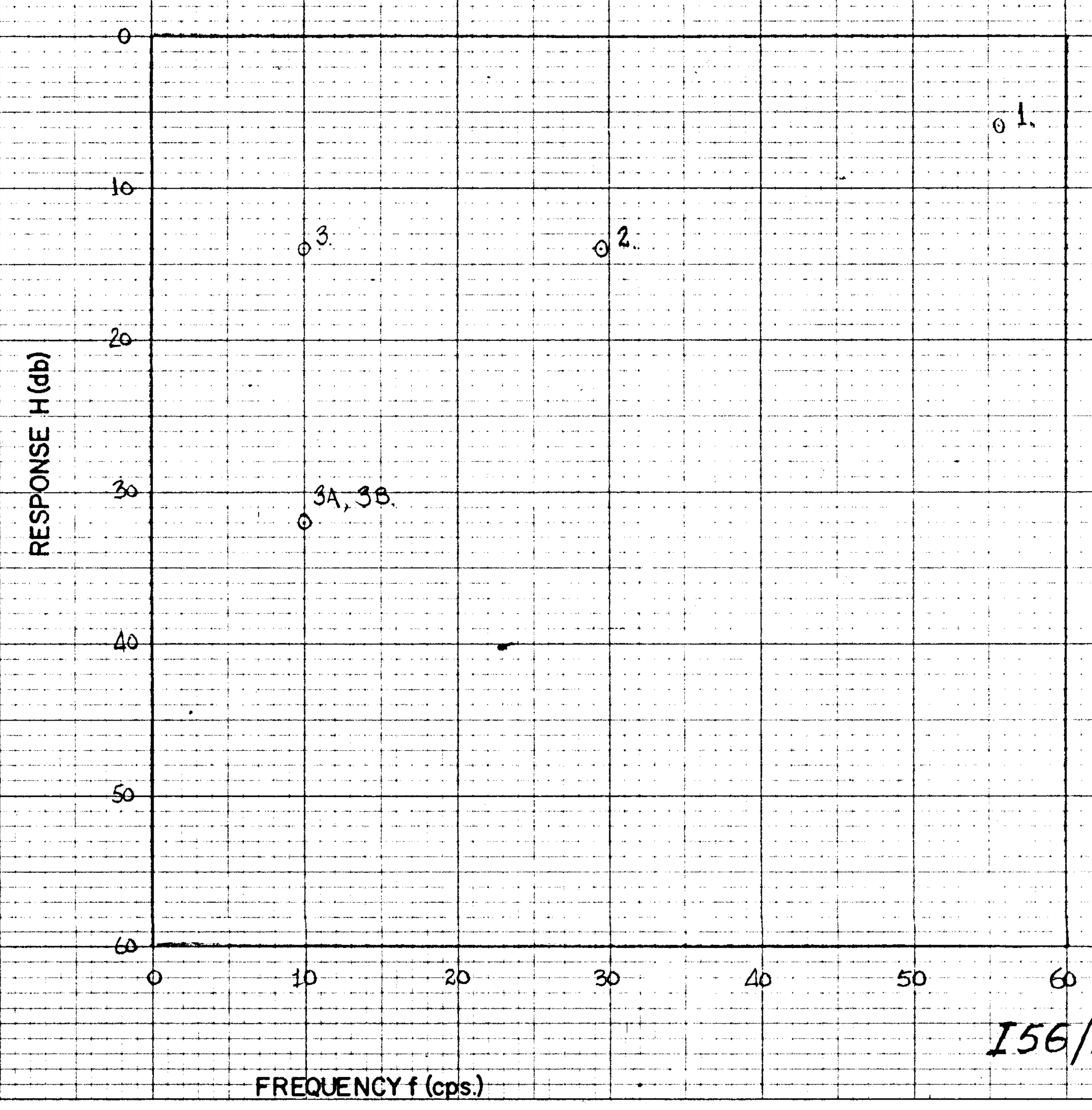


EXPERIMENTAL SEISMIC SURVEY TO COMPARE WITH VIBROSEIS.

SYDNEY BASIN 1965.

TRAVERSE H.S.2.

NOISE ANALYSIS, S.P.1487B.



I56/B3-40

CORRECTED RECORD SECTIONS

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: PREFILTERS 21c/s, 24 db/o KO-K92

A.G.C.: OFF

Gain Initial: -60

Final: Max.

Geophones: HSJ-14c/s

Geophone pattern:

as indicated

Shot-hole pattern:

9 holes, 50' apart in line

Depth 80/90'

Charge 360 lb

PLAYBACK INFORMATION

Filters: 1/20-1/60

A.G.C.: Med.

Gain Initial: -40

Final: -20

Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

Va = 12,000 ft/s (CONSTANT)

HORIZONTAL SCALE

as indicated

EXPERIMENTAL SEISMIC SURVEY FOR COMPARISON WITH VIBROSEIS SURVEY, 1965

SYDNEY BASIN

TRAVERSE HS1

GEOPHONE PATTERN COMPARISON

RECORDED BY: *Seismic Party No. 2*

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

I56/B3-30-1

CORRECTED RECORD SECTIONS

RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000B

Filters : PREFILTERS 21c/s, 24db/o KO-K92

A.G.C. : OFF

Gain Initial : -60

Final : -20

Geophones : HSJ-14c/s

Geophone pattern :

24/trace, in 2 rows in line

Geophones 20' apart

Rows 50' apart

Station interval 146·7'

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

Va = 12,000 ft/s (CONSTANT)

HORIZONTAL SCALE

as indicated

EXPERIMENTAL SEISMIC SURVEY
FOR COMPARISON WITH
VIBROSEIS SURVEY, 1965
SYDNEY BASIN

TRAVERSE HS1

SHOT-HOLE PATTERN COMPARISONS

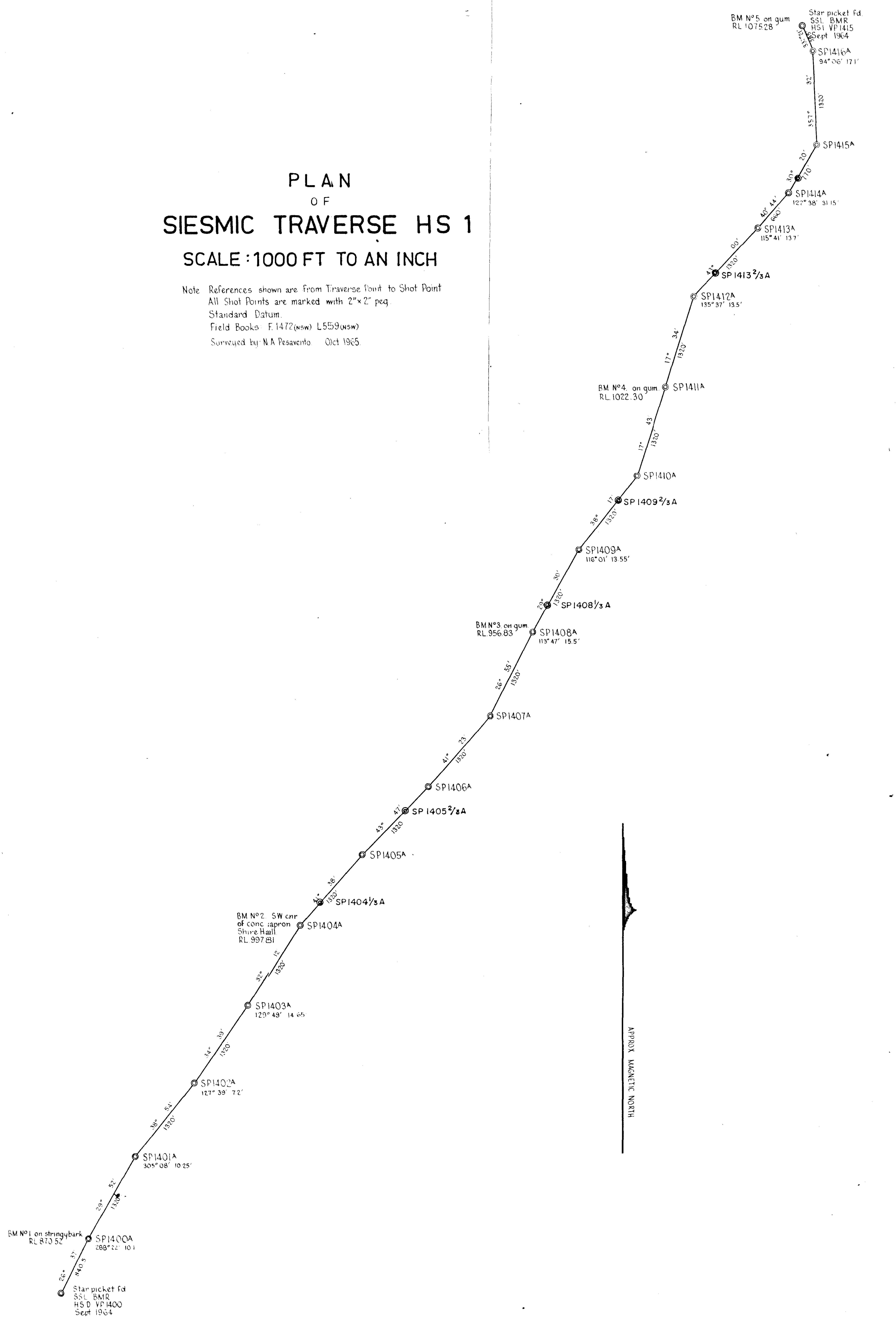
RECORDED BY: *Seismic Party No. 2*

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

I56/B3-25-

PLAN
OF
SIESMIC TRAVERSE HS 1
SCALE: 1000 FT TO AN INCH

Note: References shown are from Traverse Point to Shot Point
All Shot Points are marked with 2"× 2" peg.
Standard Datum.
Field Books F.1472(NSW) L559(NSW)
Surveyed by: N.A. Pesavento Oct 1965.



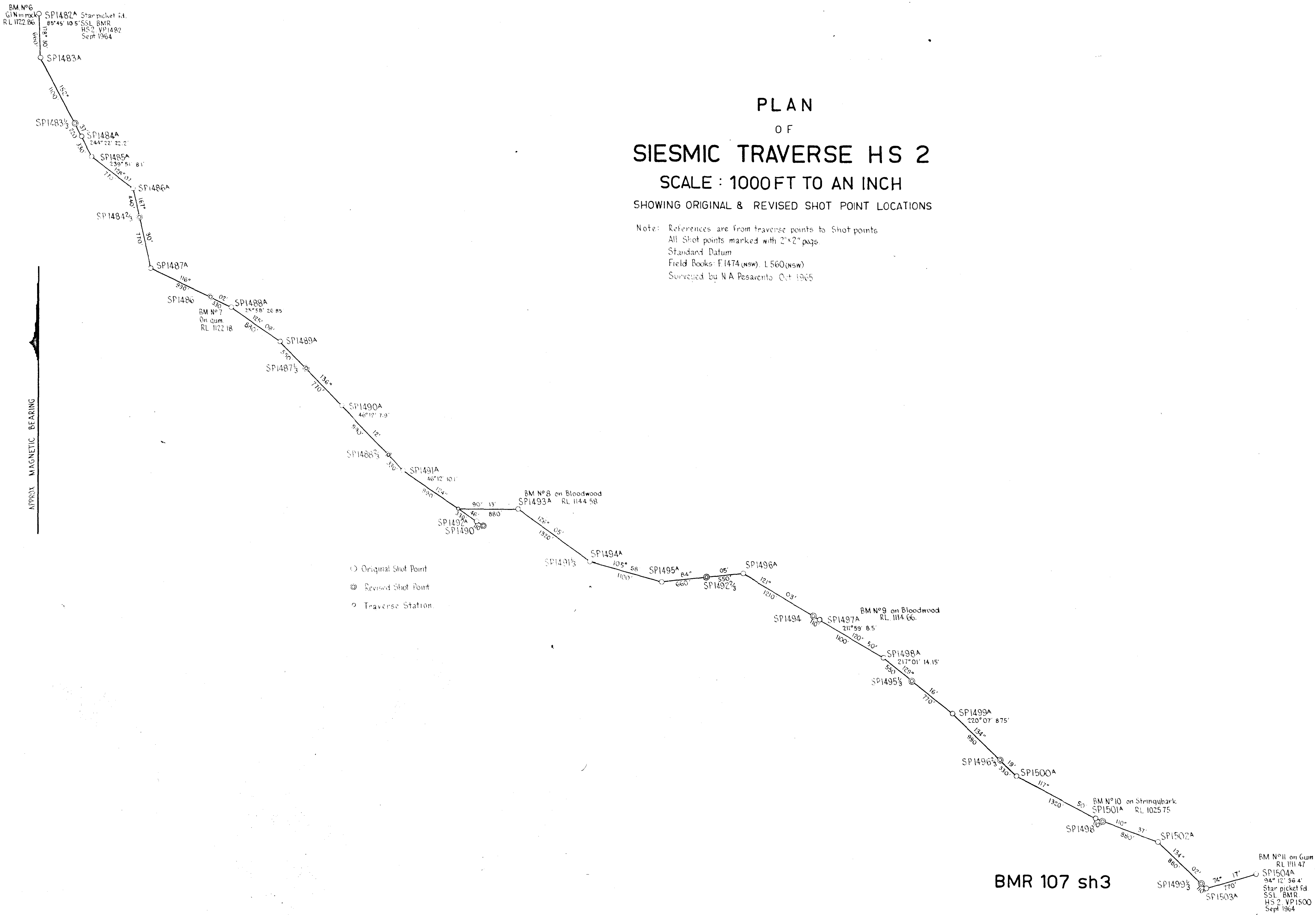
BMR 107 sh 2

I56/B3-32

Prepared by the Survey Branch, Dept of the Interior Canberra A.C.T. 1965

PLAN
OF
SIESMIC TRAVERSE HS 2
SCALE : 1000 FT TO AN INCH
SHOWING ORIGINAL & REVISED SHOT POINT LOCATIONS

Note: References are from traverse points to Shot points
All Shot points marked with 2"×2" pegs
Standard Datum
Field Books: F1474 (NSW), L560 (NSW)
Surveyed by N.A. Pesavento Oct 1965



BMR 107 sh3

I56/B3-33

PLAN
OF
SIESMIC TRAVERSES H.S. 3 & H.S. 4

SCALE : 1000 FT TO AN INCH

NOTE.

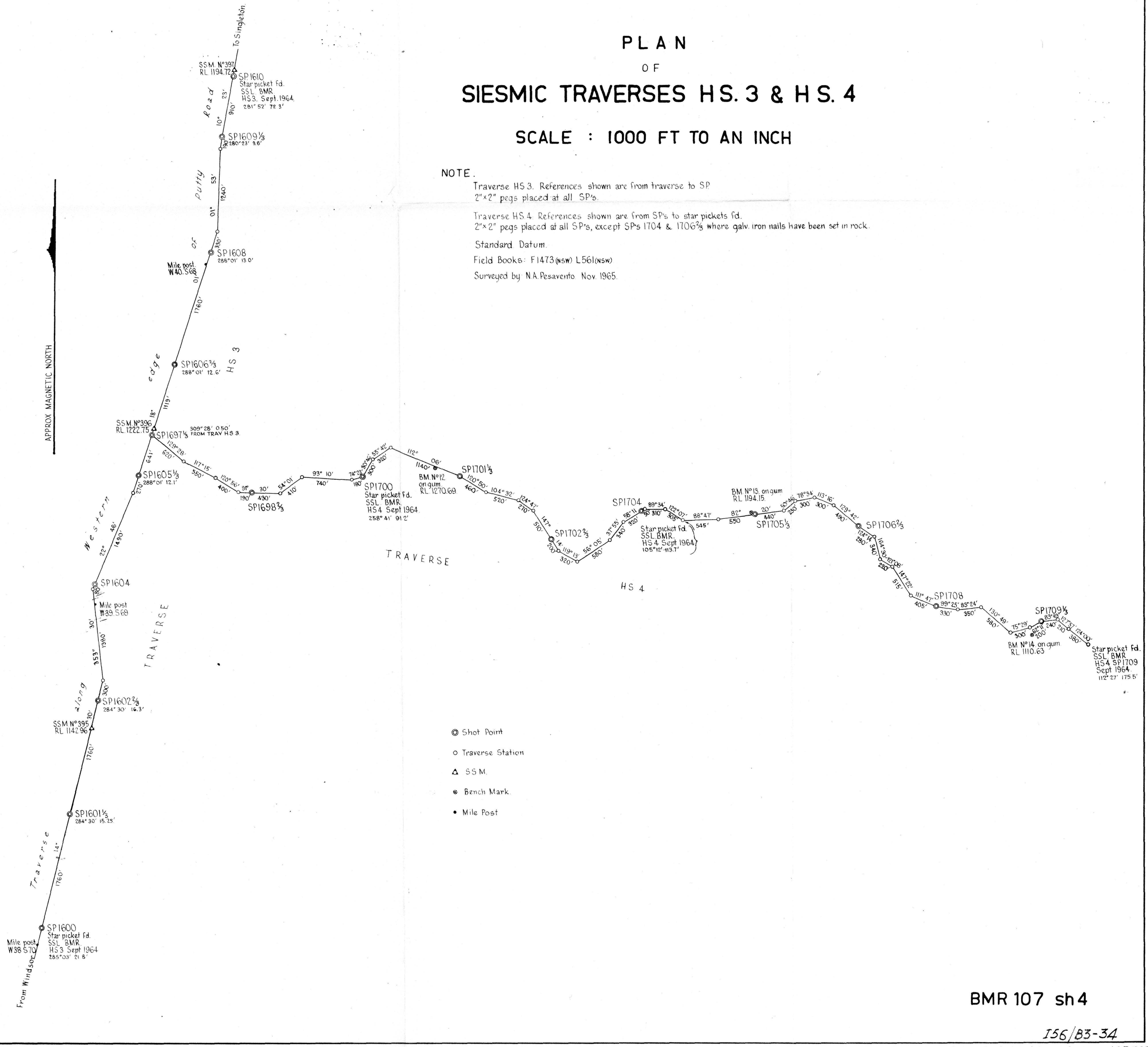
Traverse HS 3. References shown are from traverse to SP.
2"×2" pegs placed at all SP's.

Traverse HS 4. References shown are from SP's to star pickets fd.
2"×2" pegs placed at all SP's, except SP's 1704 & 1706⅔ where galv. iron nails have been set in rock.

Standard Datum.

Field Books: F1473 (NSW) L561 (NSW)

Surveyed by N.A. Pesavento Nov. 1965.



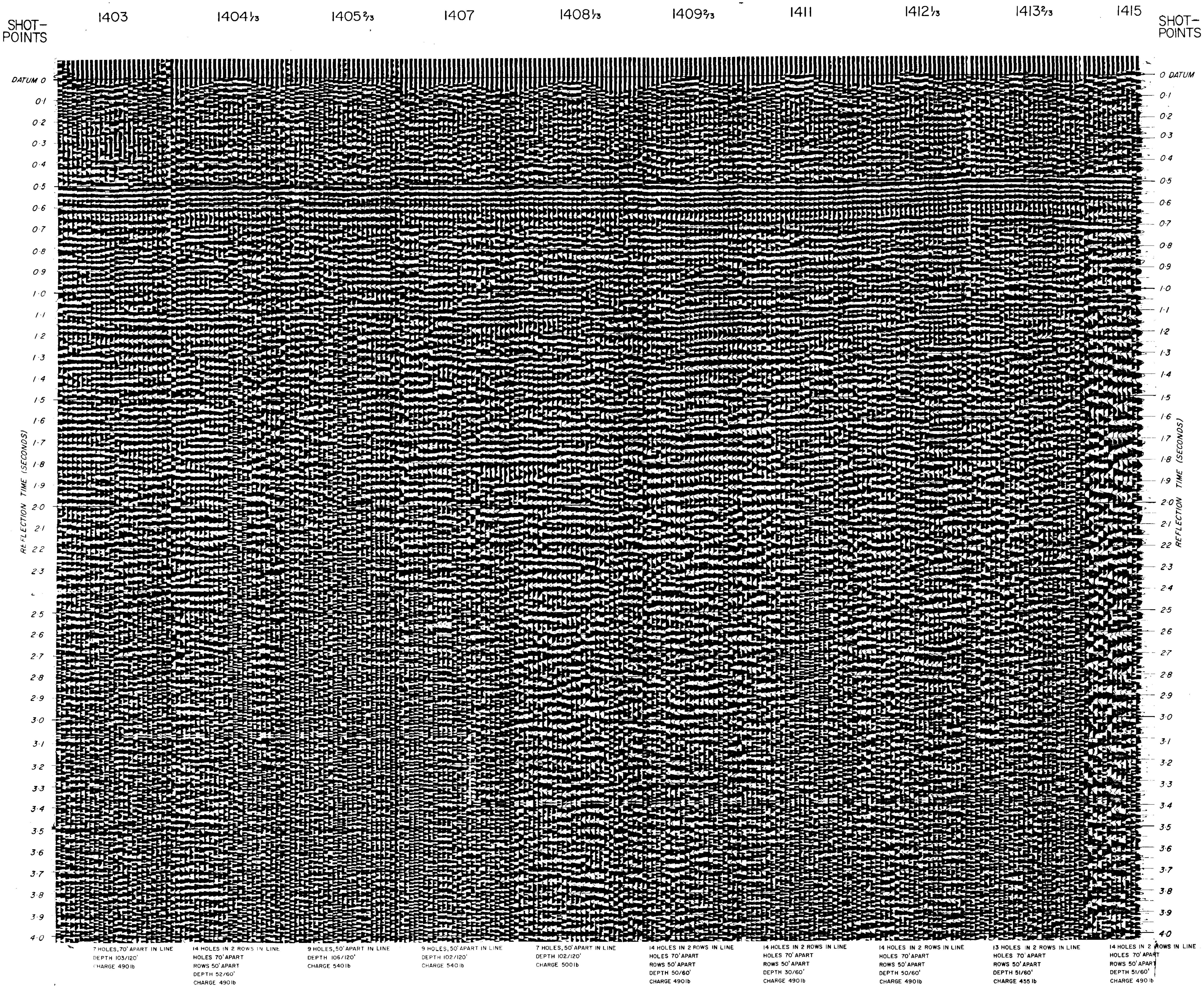
BMR 107 sh 4

I56/B3-34

Prepared by the Survey Branch, Dept of the Interior Canberra A.C.T. 1965.

PLATE 17

CORRECTED RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: PREFILTERS 21c/s, 12db/o KO-K92

A.G.C.: Med.

Gain Initial: -60

Final: Various -10 to -30

Geophones: HSJ-14c/s

Geophone pattern:

48/trace, in 2 rows in line

Geophones 20' apart

Rows 50' apart

Station interval 146·7'

Shot-hole pattern:

see section

PLAYBACK INFORMATION

Filters: 1/20-1/60

A.G.C.: Med.

Gain Initial: -40

Final: -20

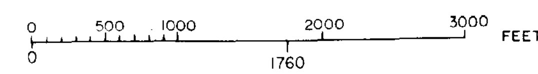
Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

Va=12,000 ft/s (CONSTANT)

HORIZONTAL SCALE



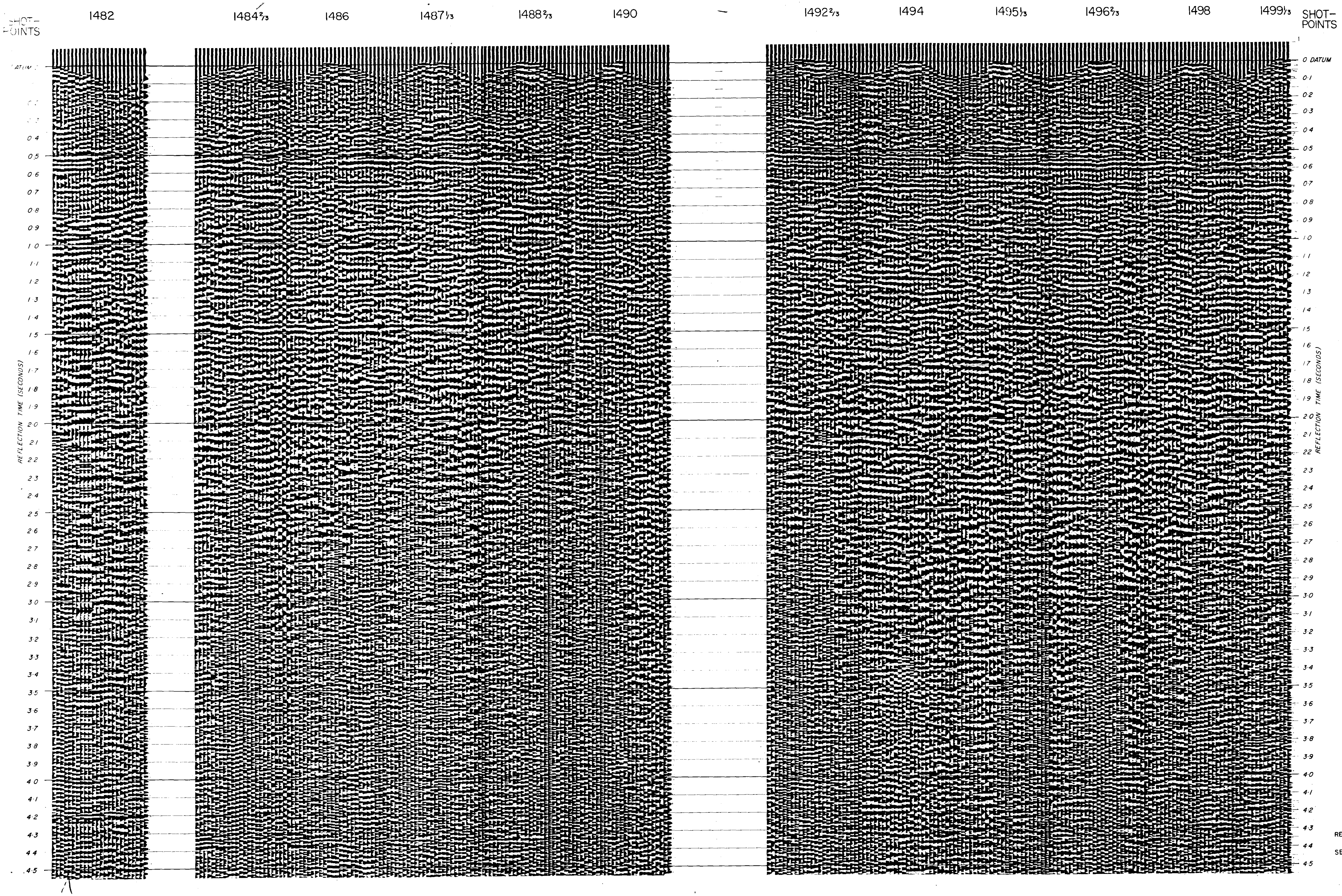
EXPERIMENTAL SEISMIC SURVEY
FOR COMPARISON WITH
VIBROSEIS SURVEY, 1965
SYDNEY BASIN

TRAVERSE HS1

RECORDED BY: *Seismic Party No. 2*

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

I56/B3-26



CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: PREFILTERS 21c/s, 12db/o KO-K92

A.G.C.: Med.

Gain Initial: -50 to -57

Final: -10

Geophones: HSJ-14c/s

Geophone pattern:

24/trace, 20' apart in line
Station interval 146·7'

Shot-hole pattern:

7 holes, 70' apart in line
Depth 60'
Charge 210 lb
SP 1484⅔ and 1486,
7 holes, 60' 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 = 12,000 ft/s (CONSTANT)

HORIZONTAL SCALE

0 500 1000 1760 2000 3000 FEET

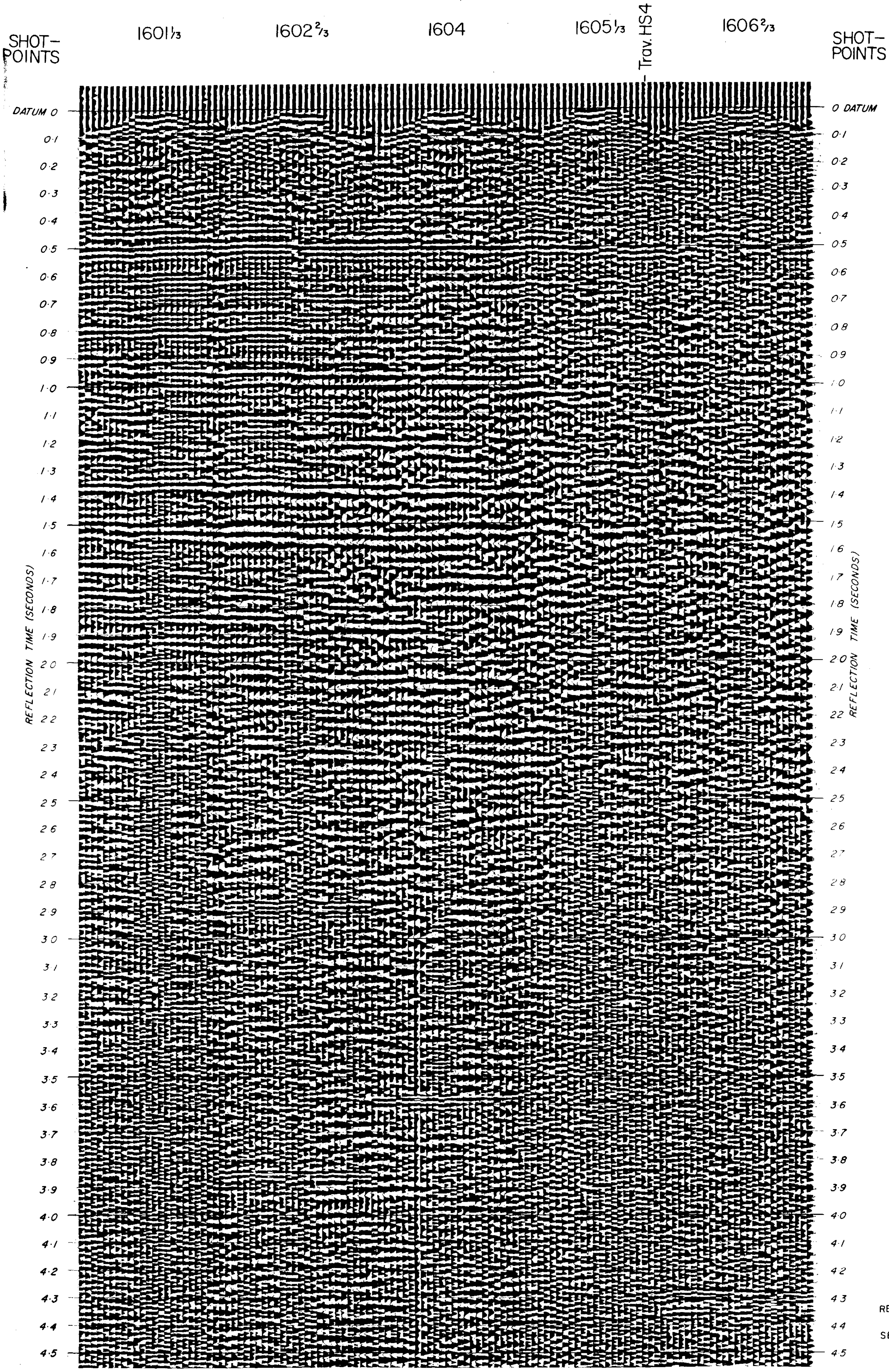
EXPERIMENTAL SEISMIC SURVEY
FOR COMPARISON WITH
VIBROSEIS SURVEY, 1965
SYDNEY BASIN

TRAVERSE HS 2

RECORDED BY: *Seismic Party No. 2*

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

I56/B3-27



CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: PMR-20

Amplifiers: 7000B

Filters: PREFILTERS 21c/s, 12db/o KO-K92

A.G.C.: Med.

Gain Initial: -60

Final: -20

Geophones: HSJ-14c/s

Geophone pattern:

24/trace, 20' apart in line

Station interval 146·7'

Shot-hole pattern:

7 holes, 70' apart in line

Depth 60'

Charge 210 lb

PLAYBACK INFORMATION

Filters: 1/20-1/60

A.G.C.: Med.

Gain Initial: -40

Final: -20

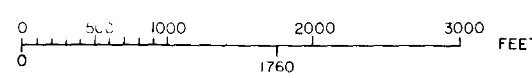
Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

Va = 12,000 ft/s (CONSTANT)

HORIZONTAL SCALE



EXPERIMENTAL SEISMIC SURVEY FOR COMPARISON WITH VIBROSEIS SURVEY, 1965

SYDNEY BASIN

TRAVERSE HS 3

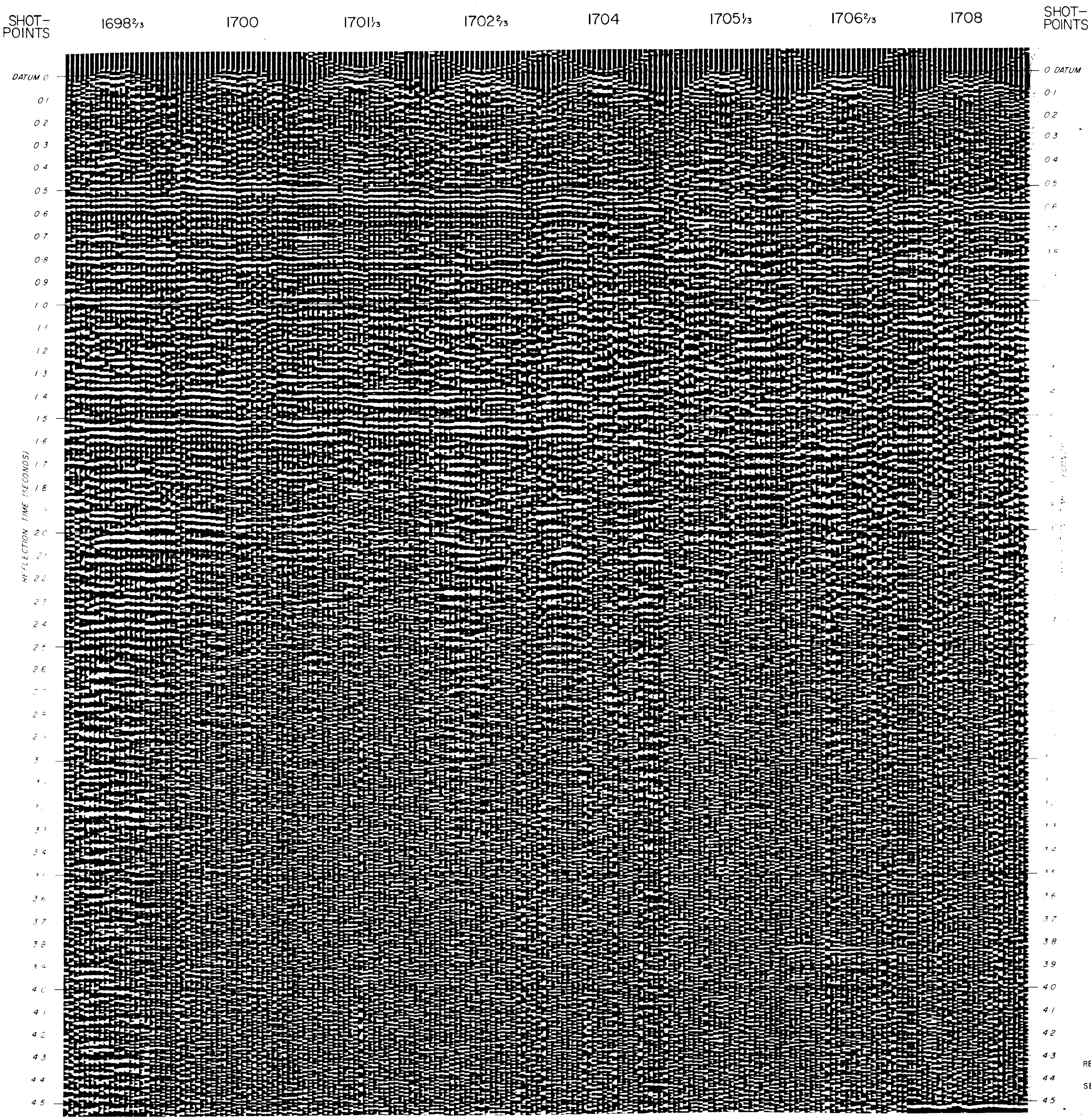
RECORDED BY: *Seismic Party No. 2*

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

I56/B3-28

PLATE 20

CORRECTED RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder : PMR-20

Amplifiers : 7000B

Filters : PREFILTERS 21c/s, 12db/o KO-K92

A.G.C. : Med.

Gain Initial : -60

Final : -20

Geophones : HSJ-14c/s

Geophone pattern

48/trace, in 2 rows in line

Geophones 20' apart

Rows 50' apart

Station interval 146·7'

Shot-hole pattern :

13 holes, 35' apart in line

Depth 60', Total charge 450lbs

SP1701⅓, 14 holes in 2 rows in line

Rows 100' apart, Holes 70' apart

SP1708, 7 holes, 70' 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 = 12,000 ft/s (CONSTANT)

HORIZONTAL SCALE

EXPERIMENTAL SEISMIC SURVEY
FOR COMPARISON WITH
VIBROSEIS SURVEY, 1965
SYDNEY BASIN

TRAVERSE HS4

RECORDED BY : *Seismic Party No. 2*

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

I56/B3-29