COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

1959 NO.151.

EXPERIMENTAL SEISMIC SURVEY

LATROBE VALLEY, VICTORIA.

APRIL , 1958.

by

K.B. LODWICK and F.J. MOSS.

RECORD 1959 NO. 151.

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ABSTRACT.

An experimental seismic survey using both refraction and reflection techniques was carried out in April, 1958, near Morwell in the Latrobe Valley at the request of the State Electricity Commission of Victoria. The object of the survey was to find if the method was of value in mapping the structure of the coal measures of the Latrobe Valley and in providing information on the depth to and type of basement underlying the coal measures.

Work was concentrated in an area south-west of Morwell on the southern limb of the Latrobe Syncline. The results obtained indicate that the seismic method may be applied successfully to geological problems of the Latrobe Valley and may provide useful control data for the interpretation of surface geological and gravity mapping. Various interpretations of the results are discussed and although some ambiguity exists, it might be overcome when more work is done, particularly if an accurate knowledge of the velocities of the coal measures is obtained. It has been possible by means of refraction work to map the extension of the basalt which crops out on the southern margin of the Latrobe Syncline beneath the coal measures with reasonable certainty.

1. INTRODUCTION.

Solution of the complex structural problems in the Brown Coal Measures of the Latrobe Valley by drilling is costly, particularly if it is desired to know the full extent of coal seams ~~to~~ a possible depth of 3,000 feet. Gravity exploration has been of great value in studying and drawing attention to the complexity of the geological structure. To develop a reliable interpretation of gravity results however, information about the density and thickness of the geological formations in several places throughout the basin is necessary. Drilling records have supplied a certain amount of information but no bore has penetrated the full section in the deeper parts of the basin and consequently information on the density and thickness of these does not exist. Seismic work could possibly supply information on the depth to basement, the presence of basalt, and the thickness and structure of the coal measures, thereby saving in drilling costs and providing greater control data for the interpretation of the gravity results. The State Electricity Commission of Victoria therefore requested the Bureau to carry out the survey under discussion in this Report.

The seismic survey was undertaken when it was thought advisable to delay a survey in Queensland where there had been heavy rain. The duration of the survey was limited to three weeks, the time of the expected delay. Two traverses were planned, the first in the Bennett's Creek area and the second between Tyers and Traralgon South

The first traverse (Traverse A, Plate 2) was surveyed from a point about one mile south east of Maryvale Siding in a south-easterly direction to the outcropping basalt and Jurassic sediments in the hills. This seismic work, using both reflection and refraction methods, was directed towards providing information on the extent of the basalt beneath the coal measures in the Traralgon Syncline, the configuration of basement, and the structure of the coal measures. The second traverse (Traverse B, Plate 2) was surveyed using the reflection method, to obtain, if possible, information on the depth to basement and structure of the coal measures. It was intended that this traverse should cross the Yallourn Fault, but it was not completed. A third traverse (Traverse C, Plate 2) was set out at right angles to Traverse A at shot point 11 and shot for refraction velocity information.

After the completion of the seismic survey, gravity readings were taken along the seismic traverses and at several new stations along roads. A semi-detailed Bouguer anomaly contour map has been drawn under the direction of Dr. Neumann of this Bureau from the new readings and existing ones and is published in this report (see Plate 2).

2. FIELD ARRANGEMENTS.

The seismic party of thirteen men including two geophysicists, an observer, two drillers, two shooters, a mechanic, and six wages hands, left Melbourne on 18th. April for Morwell in the Latrobe Valley. Accommodation was arranged for the party at State Electricity Commission Hostels. Equipment included a 24 channel Technical Instrument Company - Model 621 - seismic recording apparatus mounted in a Landrover, one Failing "750" drilling rig, a workshop truck and a Proline auger drill mounted on a Landrover.

Surveying for the party was carried out by the Brown Coal Investigation Branch of the S.E.C. The traverses (A, B and C, Plate 2) were surveyed over private property. Access for the Seismic Party was arranged by the S.E.C. who also came to an agreement with the landholders about possible damage to property caused by the seismic party's operations. The position of each traverse had to be selected with due regard to houses and power lines in order to prevent damage. Fences across the countryside at Morwell are closely spaced and proved a hind- ance to the seismic party as gates were not always in convenient places. Geophone cables were severely damaged several times when cattle chewed through the wires. This occurred mainly when long refraction spreads were used and it was difficult to keep the whole cable under continuous observation. Vehicles were parked each night in the S.E.C. yard at Morwell and storage for supplies and equipment was also arranged there. A stand-pipe in the S.E.C. yard proved to be the most convenient water supply for drilling throughout the survey. Explosives were stored in a magazine at the Australian Paper Manufacturers Mill with the permission of the mill authorities.

3. GEOLOGY.

A general outline of the geology of the Latrobe Valley is presented in this report as a basis for the discussion of results. The area is a complex one structurally and a continuous investigation is being carried out by the Brown Coal Investigation Branch of the S.E.C.

The following geological sequence has been suggested by Thomas (1953) for the coal measures in the Latrobe Valley:-

Upper	Yallourn Group	Yallourn Seam Yallourn Clay
	Morwell Group	Morwell No. 1 Seam Morwell Clay Morwell No. 2 Seam
	Yinnar Group	Clays with interbedded coals Group exhibits marked lateral variation
Lower Narracan Group	Upper	Thorpedale Volcanic suite with interbedded clays and coals.
	Lower	Childers Formation, sub-basaltic conglomerates clay and coals, etc.

The Thorpedale Volcanic suite contains thick layers of basalt.

The Latrobe Valley coal measures overlie Jurassic sediments unconformably and are in turn overlain unconformably by the Haunted Hill gravels and alluvium. In the eastern part of the Latrobe Valley, formations such as the Lakes Entrance Formation, the Gippsland Limestone, the Tambo Formation and the Jemmy's Point Formation overlie the coal measures conformably.

The geological feature associated with the Latrobe River Valley is called the Latrobe Syncline. Its trend is easterly from the Haunted Hills Fault where the Tertiary sediments in the syncline are faulted against older rocks of the Jurassic or Silurian age. The Yallourn Monocline which is faulted in places forms the northern limb of the Latrobe Syncline (Thomas, 1953). Bouguer anomaly maps of the area delineate the monoclinal or faulted northern margin very well and a drilling programme based on the gravity results has to date confirmed the conclusions drawn from the gravity work. The Carrajung monocline in the Jurassic sediments bounds the southern margin of the Latrobe Syncline (Thomas, 1953). There are three main interruptions to the gentle northerly dip of the southern limb of the Latrobe Syncline recognised by Thomas and these are listed below:-

(i) The Yallourn Syncline which is bounded on the north by the Yallourn Fault and on the west by the Haunted Hill Fault.

(ii) The Morwell anticline which develops from the Tarwin and Morwell Faults, and which separates Yallourn Syncline from

(iii) The Traralgon Syncline.

The major structural features in East Gippsland are shown together with a regional gravity map on Plate 1.

The seismic survey investigated the structural relationship between the marginal Carrajung Monocline and the Traralgon Syncline. This relationship is complicated by the occurrence of two faults which are both almost at right angles to the trend of the Carrajung Monocline, the Billy's Creek Fault and the Traralgon Fault. A further complication is the Shingle Creek Fault which although not known on the western side of the Traralgon Fault may, nevertheless, influence the structure of the sediments between the Billy's Creek and Traralgon Faults.

4. PROGRAMME.

As a large velocity difference was likely between the basalt in the Thorpedale Volcanic suite which crops out south of Traverse A, and the coal measures which overlie it, refraction work was expected to provide useful information on the extent of the basalt under the coal measures. Results of refraction shooting between shot points 1 and 5, however, revealed that energy was poorly transmitted through the sediments and reliable first arrival times could not be obtained over a distance exceeding half a mile, without using charges of excessive size. It was decided after a test shot near the northern end of Traverse A proved that reflections could be recorded, to use reflection techniques in preference to refraction shooting between shot points 5 and 14. As the sedimentary section was expected to thin to approximately 500 feet approaching the southern end of the traverse, it was necessary to use geophone spreads which extended only 1/8 mile either side of the shot point (the normal spread is 1/4 mile either side of the shot point) to ensure that the refracted energy would not interfere with the reflected energy.

Additional refraction work was carried out between shot points 1 and 17 on the southern end of Traverse A, to trace a fast velocity layer recorded between shot points 1 and 5 further towards the known basalt outcrop. Refraction work was also carried out along Traverse C at right angles to Traverse A at shot point 11 to determine the depth to a fast velocity layer and if its velocity correlated with the velocity recorded south-east of shot point 5.

On Traverse B, recording began at the southern end and it was thought desirable to use geophone spread lengths of 1/4 mile either side of the shot point, if possible, in order to survey as much of the traverse as possible in the limited time left. Test shots were fired using spread lengths of 1/4 and 1/8 mile either side of the shot point. Although the results using 1/8 mile spread were of better quality, the 1/4 mile spreads were chosen as sufficient clear reflections could be recorded using that technique to warrant sacrificing quality and accuracy for the greater coverage possible.

Several filter settings on the TIC Model 621 recording equipment were tried for the reflection shooting, and the setting L22 H33 corresponding to a band pass of 35 cycles per second to 55 cycles per second (see Plate 9) was found to be the most satisfactory.

For reflection work six twenty cycle per second geophones were used per trace and were spread at intervals of 11 feet along the line of the traverse. Results were satisfactory but no experimental work was done varying the spacing of the geophonesor the number per trace to see if they could be improved.

Single six cycle per second geophones were used for refraction work throughout the survey.

5. RESULTS.

(a) Refraction Work - Traverse A.

Results of the refraction work carried out between shot points 5 and 17 at the southern end of Traverse A are shown on Plate 3 where the arrival times of the first refracted energy detected at each geophone are plotted against the distance of the geophone from the shot point. The velocities of three different layers were measured when shooting from shot points 3 and 5 but only two different velocities were distinguishable when shooting from shot points 1, 15 and 16½. The fastest apparent velocities measured were 18,480 feet per second in a south easterly direction and 11,000 feet per second in a north westerly direction between shot points 5 and 15. These apparent velocities are interpreted as being from one refractor with a true velocity of 13,400 feet per second dipping to the north-west at about 7 degrees. The highest velocities recorded between shot points 15 and 17 indicate a refractor with a true velocity of 12,300 feet per second dipping at 4 degrees to the north-west. These two calculated true velocities (13,400 feet per second and 12,300 feet per second) agree within the limits of accuracy of the measurement of velocity by the refraction method, and it is likely that they are recorded from the same layer. Even if the velocities were both accurate it is conceivable that as the layer becomes shallower, it [illegible] become weathered and this may account for the slightly lower velocity recorded between shot points 15 and 17. Assuming, then, that the velocitiesof 13,400 and 12,300 feet per second were recorded from the same layer, depths to this layer were calculated and the profile drawn from the results is shown on Plate 3. In the depth calculations, an average of the velocities measured for layers above the 13,400 feet per second layer was used.

It was possible to time the arrival of energy refracted along the highest velocity layer on only a small number of traces which indicates that there was a large attenuation of energy in this layer. The small number of points on which the value of the high velocity was calculated places the reliability of the refraction results in some doubt. The conclusions drawn from the results, however, are consistent with reflection work, geology and more recently drilling information (see Section 6 - Interpretation). The poor return of energy was disappointing particularly when basalt was expected to underlie the coal measures. Large charges were tried; the largest was 145 lb. at a depth of 90 feet at shot point 15 but even this failed to produce readable first breaks a mile and a quarter away. One suggestion for the attenuation of seismic energy in the high velocity layer is that basalt is layered (lit-par-lit structure) and does not transmit energy of the wavelength of the seismic energy as there is no bed thick enough.

(b) Reflection Work - Traverse A.

The seismic reflection cross-section between shot points 5 and 14 is shown on Plate 4. The cross-section is plotted on a natural scale relative to a datum of 250 feet above M.S.L. Above the cross-section the elevation, drill logs and the thickness of a low velocity surface layer (the weathered layers) are plotted on an exaggerated scale. The velocity of the strata immediately below the weathered layer may be derived from the refraction breaks on the record from each shot point and is plotted below the cross-section. On the reflection cross-section, a single reflection is denoted by as many parallel lines as there are cycles in phase on the oscillograph record. The reflection symbols have been plotted vertically below the shot point at which they were recorded so that reflections from dipping reflectors are not plotted in their true positions.

The time of a reflection is measured on the record and to present this in terms of depth (as shown on the cross-section), the distribution of velocity throughout the sedimentary section has to be determined. In the absence of velocity data from bore holes, a statistical analysis of reflections was made to determine the velocity distribution. An error of as much as 10% may be inherent in velocity distribution derived by this method.

The reflection cross-section along Traverse A (Plate 4) has been plotted using a time-depth relation derived from the above velocity distribution (Plate 7). A sharp increase in the Interval Velocity at about 550 milliseconds is noticeable on the Interval Velocity Curve (Plate 7). This almost certainly corresponds to a change in character of the stratigraphic section. It appears from the cross-section (Plate 4) that this change in character is not likely to be at a constant depth but dips to the north-west. In this case the time-depth relation used in plotting the cross-section will not be correct over the whole length of Traverse A.

The errors in reflection plotting are of importance in the discussion of the results of refraction work along Traverse C (Section 5(c)).

Good to fair quality reflections were recorded in the earlier parts of the record on the northern end of Traverse A. Towards the south-east however the section became shallower and reflection quality deteriorated. At a depth of about 2,000 feet below shot point 13, a change of character of the cross-section is noticeable and it may be followed along the cross-section as far as shot point 8. The change, above which reflections are of much better quality than those below, is even more apparent on the records than on the cross-section. Dips of the reflections above and below this change indicate that it does not represent a marked angular unconformity. Another change in character of the cross-section may be distinguished at a depth of about 2,600 feet, beneath shot point 13, below which reflections are fewer and of poorer quality than above. This second change may also be followed as far as shot point 8. The reflections below the change again indicate dips similar to those recorded above the change.

As an aid to the interpretation of the cross-section which follows in a later section (Section 6) of this report, three phantom horizons have been drawn. The first phantom horizon which represents the structure indicated by reflections recorded above the first change in character of the cross-section has been derived by correlating an arbitrarily chosen reflection 1,000 feet below datum at shot point 13 from one shot point to the next. Similar phantom horizons may be drawn from the other reflections above the first change in character of the cross-section. The second phantom horizon has been drawn along the first change in character of the cross-section by progressively following the mean of the dips of reflections recorded between the two changes in character of the cross-section. The third phantom horizon has been drawn along the second change in character of the cross-section by progressively following the mean of the dips of reflections below it.

Beneath shot point 9 a small anticlinal feature is noticeable in the shallower reflections and its relief increases with depth. Reflections in the band between the two changes in character indicate a reflecting surface steeply dipping away from shot point 9 on both sides.

A sharp discontinuity in the correlation of reflections from one shot point to the next is evident beneath shot point 8 and a less pronounced one can be seen beneath shot point 6½.

(c) Refraction Work - Traverse C.

The geophone spread used for the refraction work along Traverse C was one mile long and assuming likely values for the velocities of the expected fast refracting layer and the sediments above it, calculations indicated that the nearest geophone should be about 2 miles from the shot point. It was desirable that the energy recorded at the geophones from the two shot points, one at each end of the traverse, be refracted from the same part of the refractor. In order to do this, the geophone had to occupy different positions when recording energy from each shot point in turn. The time distance curve (Plate 5a) shows the position of the geophones in relation to the shot points and Traverse A. The derivation of the profile of the refractor is illustrated on

Plates 5b and 5c. The times of arrival of the refracted energy have been corrected for weathering and elevation. The true velocity of the refractor was calculated from the apparent velocities in opposite directions. Theoretical times of arrival of refracted energy at each geophone were then calculated from the true velocity and are the same as those which would be recorded by the geophones from the refractor if it were a plane horizontal surface. The difference between the times actually recorded and the theoretical times at each geophone is a function of the variation in depth of the actual refracting layer at each geophone point. From these differences profiles of the refractor were drawn for each geophone spread. The profiles were then superimposed in a position where their shape was matched as nearly as possible. A mean of the profiles was drawn and plotted in terms of depth below datum (250 feet above Mean Sea Level).

Apparent velocities of 13,500 and 15,250 feet per second were recorded from shots at points 18 and 19 respectively, and it was calculated that they represent a refractor with a true velocity of 14,300 feet per second dipping at about 2 degrees to the south-west. In calculating the depth of the refractor a single layer was assumed to overlie the refractor, and the depth obtained will depend on the average velocity chosen for the layer. Depths of 1990, 2,200 and 2,440 feet were calculated from assumed velocities of 5,500, 6,000 and 6,500 feet per second respectively. As there are some errors in the plotting of reflections on the cross-section (Plate 4) due to the velocity distribution used (Section 5b), a comparison of the depths of the refractor with the plotted depths of reflections on the cross-section is not permissible. A more realistic comparison may be made by converting the depths of the refractor into equivalent reflection times and then plotting them using the velocity distribution assumed for plotting the reflections (Plate 7). The various depths (1,990, 2,200, 2,440 feet) of the refractor for the corresponding velocities are thus plotted on the reflection cross-section relative to the plotted reflections. As expected, the plotted positions of the depths of the refractor correlate with the same reflecting horizon (see Plate 4). The velocity of 6,000 feet per second is probably nearest to the true value of the average velocity of the sediments above the 14,000 feet per second refractor. It is possible depending on the various thicknesses of clays and coal strata that the velocity could be as low as 5,500 feet per second or as high as 6,500 feet per second. In terms of depths the refractor is between 1,990 and 2,440 feet and is probably at a depth of 2,200 feet (i.e. 2,200 ± 200 feet).

(d) <u>Reflection Work - Traverse B.</u>

A seismic reflection cross-section using a similar type of presentation to that of Traverse A (see Section 5b and Plate 3) is shown on Plate 6. Along this traverse shot holes were spaced quarter of a mile apart and the information provided is of poorer quality than on Traverse A where shot holes were spaced at one eighth mile intervals. A well defined band of reflections between 1,400 and 2,200 feet are of fair quality and indicate a shallow synclinal feature with its axis beneath shot point 25. Above this band reflections are few and no reliable information was obtained. The reflection quality is poor below about 2,200 feet and is similar in character to that beneath the second change in character on Traverse A.

(e) <u>Gravity Work.</u>

Sixtysix new gravity stations were read including the shot points along the seismic traverses. Worden Gravimeter No. 61 was used for the survey and although the drift rates were sometimes erratic, reliable results for a semi-detailed survey were obtained. The useful life of the suspension in the gravimeter may be near its end and this will entail readjustment by the makers.

No major changes were necessary in the Bouguer Anomalies already published (Neumann 1951). A Bouguer Anomaly map incorporating the results of the recent survey with older work is presented on Plate 2. Neumann (1951) derived contours of the depth of the basalt from gravity data and bore hole information. The contours indicate a gradual deepening of the basalt along Traverse A from its outcrop in the hills at the southern end to about 1,500 feet below sea level at the northern end. A Bouguer Anomaly profile along Traverse A is shown in Plate 8. Gravity readings were made at each shot point (one eighth mile apart) and a more detailed knowledge of the gravity gradients along the traverse than previously known is provided. Two small changes in gradient at shot points 8 and 10 will be discussed in the section of Interpretation (Section 6).

6. <u>INTERPRETATION.</u>

Basalt is known to crop out about half a mile south-east of shot point 17, on Traverse A, and it was expected to dip beneath the coal measures for at least a short distance to the north-west and it may be present throughout a great part of the Latrobe Valley. The velocity of 13,000 feet per second measured by refraction work between shot points 5 and 17 is a reasonable value for basalt (Heiland, Geophysical Exploration, P472) and taking into account the dip of the profile on Plate 3, it is reasonable to assume that the top of the basalt is represented by the profile of the 13,000 feet per second layer. Since the completion of the seismic work information on two bores has come to hand. (Gloe, personal communication). The depth to basalt in the bores is plotted on Plate 3 and the agreement with the profile confirms that the 13,000 feet per second layer is basalt.

The depth of basalt from refraction work is shown beneath shot point 5 on Plate 4 and it may be correlated confidently with a band of reflections at a depth of about 940 feet below shot point 6. It is possible to follow the reflection to a depth of about 1,400 feet below shot point 8. The discontinuity in correlation beneath shot point 6½ may be interpreted as a small fault with a throw of 100 feet or less and downthrown to the north-west.

In the sedimentary sequence of the Latrobe Valley presented by Thomas (1953) two major changes in character are evident. It seems a logical interpretation of the reflection cross-section between shot points 8 and 14 to correlate the first geological change at the top of the basaltic Narracan Group with the first break in character of the reflection cross-section (i.e. at 2,000 feet below shot point 13 and indicated by the second phantom horizon on Plate 4) and the second geological change at the top of the Jurassic with the second break in the character of the reflection cross-section (i.e. at 2,600 feet below shot point 13 and indicated by the third phantom horizon on Plate 4).

A serious argument against this interpretation arises from the results of refraction work. The velocity of 14,000 feet per second, which was recorded beneath shot point 11 seems too high for the Jurassic sediments even at a depth of 3,000 feet and it is more likely that of basalt. If the velocity of 6,000 feet per second for the assumed single layer above the 14,000 feet per second refractor (this agrees closely with the average velocity derived from the statistical analysis of reflections, Section 5c and Plate 7) is assumed to be correct, the most probable value for the depth of this high velocity layer (representing the basaltic Narracan Group) is 2,200 feet which corresponds with the second break in character of the reflection cross-section (see Plate 2), not the first as suggested above.

Two modifications which would bring agreement between the suggested interpretation of reflection work and the results of the refraction work are:-

(a) That a significant change in the sedimentary character of the Upper Latrobe Valley Coal Measures may exist which could account for the first break in uniformity of the reflection cross-section, thus allowing part of the upper coal measures to be represented by the reflections between the two breaks in uniformity.

(b) That basalt of sufficient thickness to be recorded by refraction methods may not exist in the sedimentary sequence on this part of the traverse and the velocity of 14,000 feet per second may represent the Jurassic sediments. It is considered unlikely that the velocity recorded is that of the Jurassic sediments if basalt of sufficient thickness exists above them.

The sharp break in correlation of reflections from one shot point to the next beneath shot point 8 is almost certainly a fault, down-thrown on the north-west. An estimate of the magnitude of the throw will depend on the interpretation of the reflection cross-section between shot points 8 and 14. If the second phantom horizon represents the top of the basalt as postulated by the original interpretation of the reflection profile the throw would be about 200 feet and if the third phantom horizon represents the basalt the throw would be about 800 feet.

Interpretation of gravity results (Neumann 1951) was made on the assumption that basalt existed beneath the coal measures of the Latrobe Valley and that the Bouguer anomalies could for the main part be explained by the density difference between the coal measures and the basalt. A fault with a throw of about 800 feet as suggested beneath shot point 8 would be expected to produce a gravity gradient much greater than indicated on the Bouguer anomaly profile (Plate 8). The small Bouguer anomaly gradient seems to indicate that a throw of about 350 feet is more likely and this would in turn suggest that the top of the basalt corresponds to the second phantom horizon and not the third.

The small gravity gradient beneath shot point 10 corresponds to a slight flexure in the reflection cross-section (Plate 4). There is no evidence in the gravity work however to confirm the small fault postulated from the reflection cross-section beneath shot point 6½.

7. CONCLUSION.

The interpretation of the seismic results south-east of shot point 8 on Traverse A is well founded and at shot point 1 the depth to the basalt has been confirmed by drilling. Between shot points 8 and 14 however the gravity interpretation cannot be reconciled with an interpretation that satisfies both the reflection and refractor results. The reflection and gravity results together suggest that the basaltic Narracan group is likely to correspond with the second phantom horizon on the reflection cross-section. This would in turn indicate that the fault beneath shot point 8 has a throw of about 200 feet. The reflection and refraction results taken together suggest that the basaltic Narracan group corresponds with the third phantom horizon. The fault beneath shot point 8 would in this case have an indicated throw of about 800 feet. The gravity results suggest that 800 feet is too great and that 350 feet is a more likely value.

If it were possible to extend the third phantom horizon to a depth of 1,750 feet below shot point 8 and to disregard the dotted portion shown, the gravity reflection and refraction results would all indicate that the basaltic Narracan group is likely to correspond with the third phantom horizon. The quality of reflections recorded beneath shot points 8 and 8½ is not sufficiently high to prove this possibility.

In any future work in the Latrobe Valley, it is important that a better knowledge of the velocities of the coal measures is obtained. This may be done by shooting a reflection spread near a bore such as the Australian Paper Manufacturers Water Bore where the stratigraphic succession is known in detail, and correlating reflecting horizons with geological horizons. In addition, special reflection spreads to measure velocities (Gardiner 1947) may be of some help. The refraction work along Traverse C (at right angles to Traverse A) should be supplemented by setting out short refraction spreads along Traverse C and shooting from both shot points 18 and 19. A better knowledge of the velocities of the sediments above the 14,000 feet per second refractor would thus be obtained and the present difficulties in interpretation might be consequently resolved.

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PLATE I
GEOPHYSICAL SURVEY,
EAST CENTRAL GIPPSLAND, VICTORIA
MAJOR STRUCTURAL FEATURES
AND GRAVITY CONTOURS
SHOWING SEISMIC TRAVERSES
LEGEND
ROAD
RAILWAY
OIL BEARING AREA
GRAVITY CONTOUR
MONOCLINE, FAULT Geologically known
" Geophysically indicated
ANTICLINE Geologically known
" Geophysically indicated
TECTONICAL TREND Geol. known
" " Geoph. indicated
EXPLANATION
Contours show Bouguer values relative to an arbitrary datum. An average density of 1.887 has been assumed for rocks between station site and sea level in reduction of gravity values.
To convert to Bouguer Anomalies relative to theoretical values on International Ellipsoid (density σ = 2.67), subtract from values shown:
(9.13 + 0.01 × h) milligal,
where 'h' is the station altitude in feet above Sea Level.
SCALE
MILES 4 0 4 8 12 16 20 MILES
CONTOUR INTERVAL 5 MILLIGALS
LOCATION DIAGRAM
MELBOURNE
GEOPHYSICIST
DATE
G93-64
GEOPHYSICAL SECTION BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS
37° 45'
38° 00'
38° 15'
38° 30'
38° 45'
146° 00'
146° 30'
147° 00'
147° 30'
147° 45'
148° 30'
BASS STRAIT
NINETY MILE BEACH
LAKE WELLINGTON
LAKE KING
LAKE VICTORIA
LAKE REEVE
CORNER INLET
MITCHELL RIVER
AVON
MACALISTER
THOMSON
LATROBE
PRINCES HIGHWAY
Bairnsdale
Bengworden
Briagolong
Boisdale
Maffra
Heyfield
Stratford
Sale
Longford
Rosedale
Traralgon
Morwell
Yallourn
Moe
Trafalgar
Yarragon
Lakes Entrance
Stradbroke
Seaspray
Gormandale
Carrajung
Boolarra
Mirboo North
Woodside
Yarram
Alberton
Welshpool
Foster
Toora
Meeniyan
Yarragon Fault
Fish Creek Fault
Toora Fault
Tarra Tap Fault
Carrajung Monocline
English Corner Monocline
Yarram Anticline
Barriman Anticline
Monkey Creek Fault
Merriman Creek
Loy Yang Dome
Syncline
Edge of South Gippsland Block
TARRA RIVER
SOUTH

SCALE IN MILES

Contour Interval 1 Milligal

EXPERIMENTAL SEISMIC SURVEY, LATROBE VALLEY, VICTORIA.

MORWELL-TRARALGON AREA

BOUGUER ANOMALY MAP AND SEISMIC TRAVERSES

LEGEND

- Seismic Traverse
- Gravity Contours
- • 176 Gravity Station 1958
- Earlier Gravity Station
- Relative Bouguer Anomaly
- Road
- Railway
- B61 Bore Hole

EXPLANATION

Contours show Bouguer values relative to an arbitrary datum. An average density of 1.88 has been assumed for rocks between station site and sea level in reduction of gravity values.

To convert to Bouguer Anomalies relative to theoretical values on International Ellipsoid (density σ=2.67), subtract from values shown:

(3.13 + 0.01xh) milligal,

where 'h' is the station altitude in feet above Sea Level.

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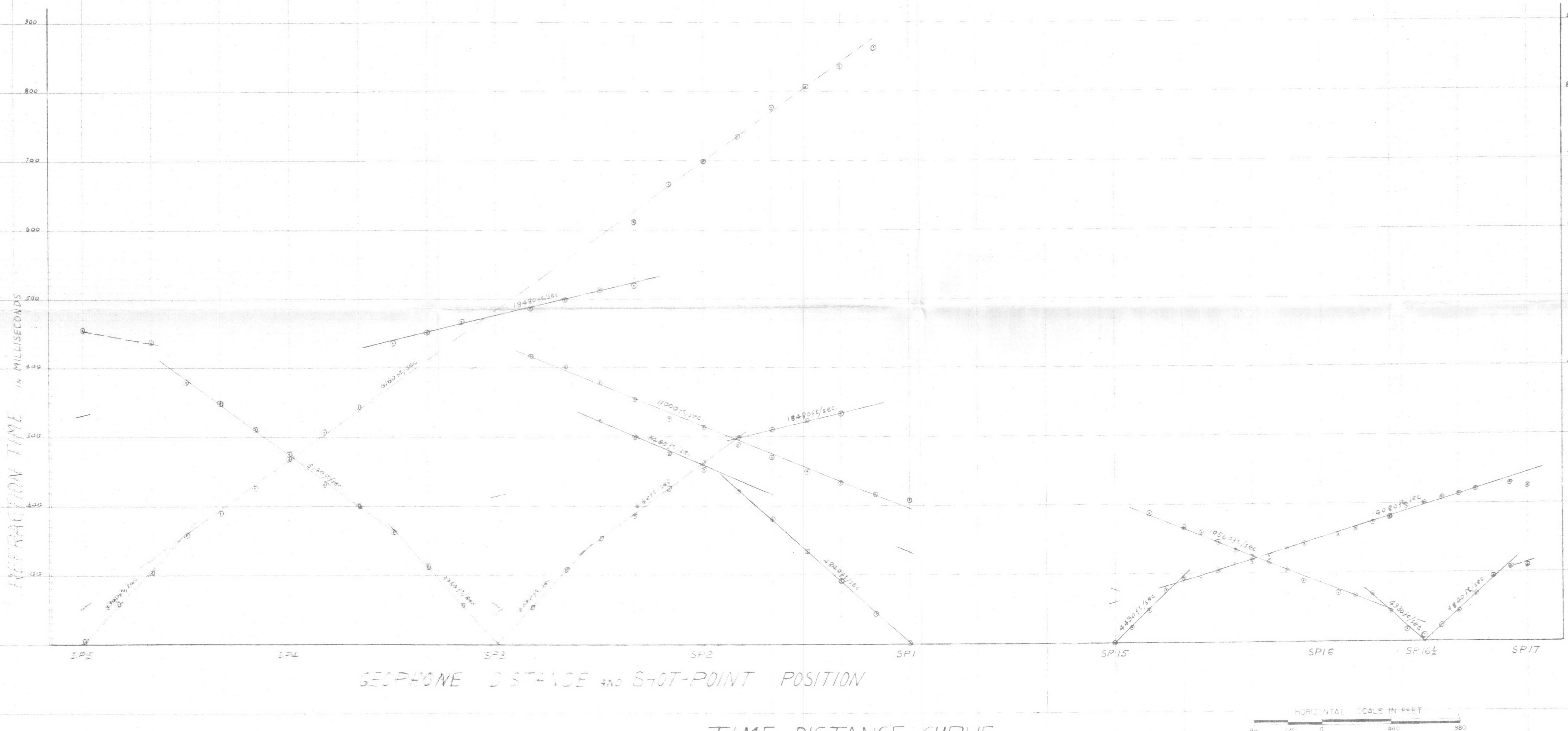
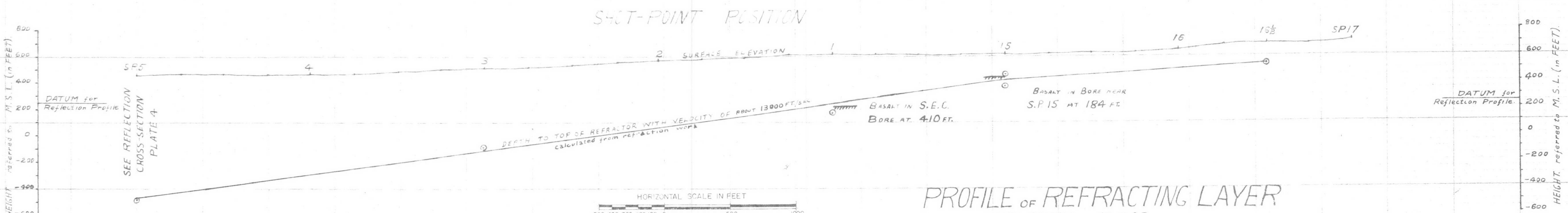


TIME-DISTANCE CURVE



PROFILE OF REFRACTING LAYER
HAVING A VELOCITY OF 13,000 FEET PER SECOND

EXPERIMENTAL SEISMIC SURVEY, LATROBE VALLEY, VIC.

SEISMIC REFRACTION RESULTS TRAVERSE A

(BENNETT'S CREEK)

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G 93-60

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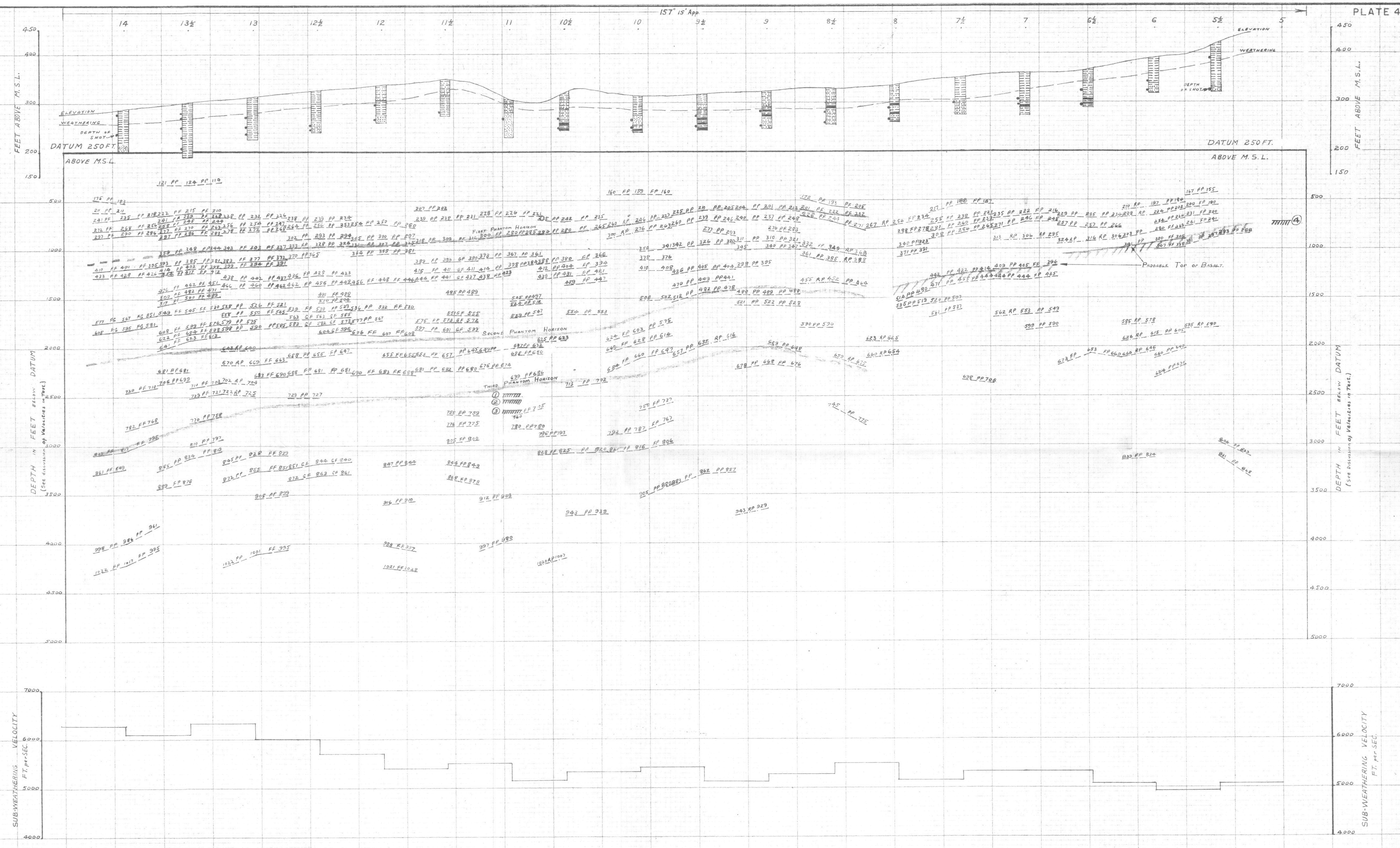

LEGEND

DRILL LOGS

- Clay
- Sand
- Coal

CROSS-SECTION

- Good quality reflection
- Fair quality reflection
- Poor quality reflection
- Doubtful quality reflection

(1) Depth to top of layer with a velocity of 14000 ft per second, assuming an average velocity of 5500 ft. per second for the sediments above it (1990 ft.)

(2) As above. Assuming velocity of 6000 ft. per second (2200 ft.)

(3) As above. Assuming velocity of 6500 ft per second (2440 ft.)

Note: Above depths converted to equivalent times and shown relative to plotted reflections.

(4) Depth to top of layer with a velocity of 12000 ft per second at shot point 5. Measured velocity of Overlying Strata 5800 ft per second.

PHANTOM HORIZONS

FIRST PHANTOM HORIZON: Derived by correlating an arbitrarily chosen reflection (1000 feet below datum at S.P. 13) from one shot point to the next.

SECOND PHANTOM HORIZON: Drawn along the first change in character of the cross-section by progressively following the mean of the dips of the reflections between the two changes in character of the cross-section.

THIRD PHANTOM HORIZON: Drawn along the second change in character of the cross-section by progressively following the mean of the dips of reflections below it.

EXPERIMENTAL SEISMIC SURVEY, LATROBE VALLEY, VIC.

SEISMIC REFLECTION CROSS-SECTION TRAVERSE A (BENNETT'S CREEK)

UNMIGRATED CORRELATION SECTION

HORIZONTAL SCALE IN FEET

500 400 300 200 100 0 500 1000

Geophysical Section, Bureau of Mineral Resources, Geology & Geophysics.

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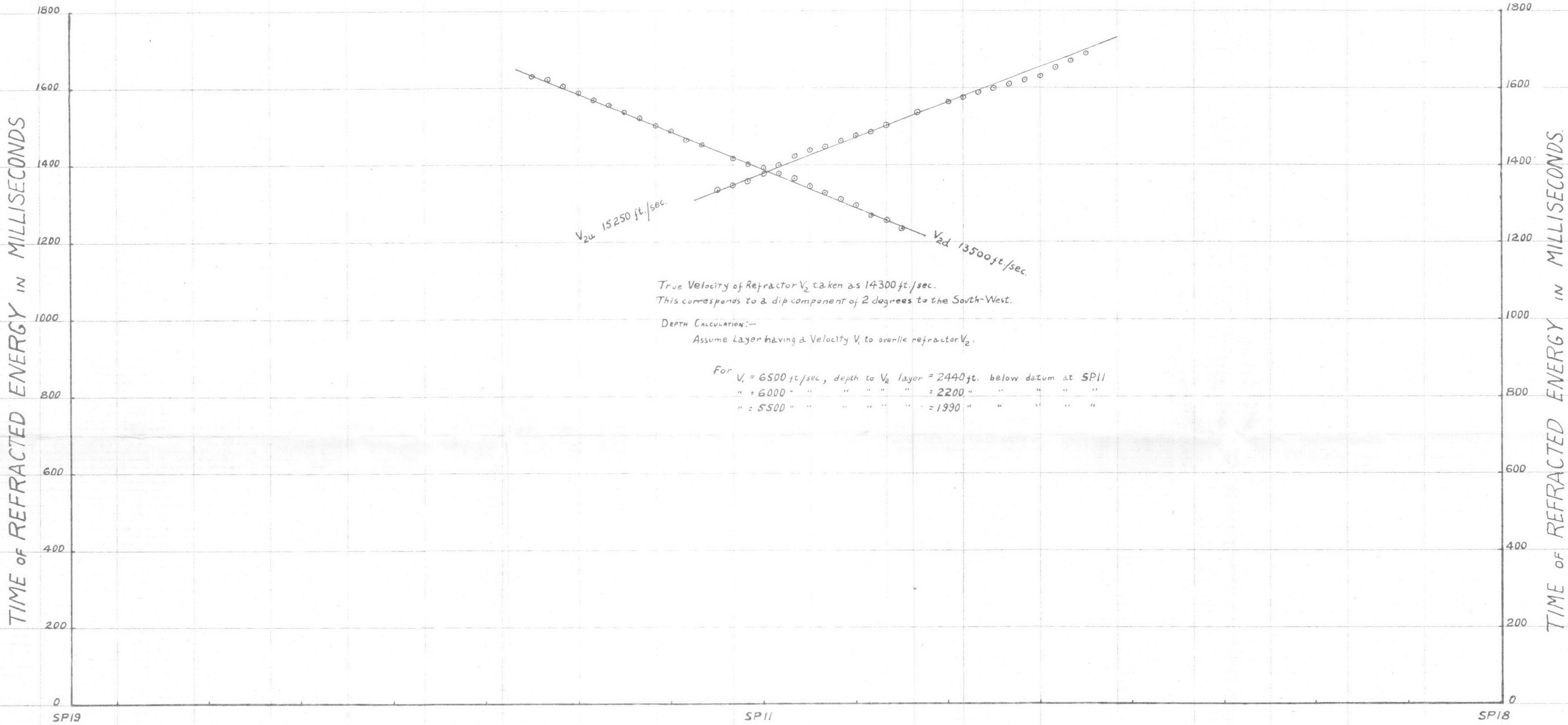
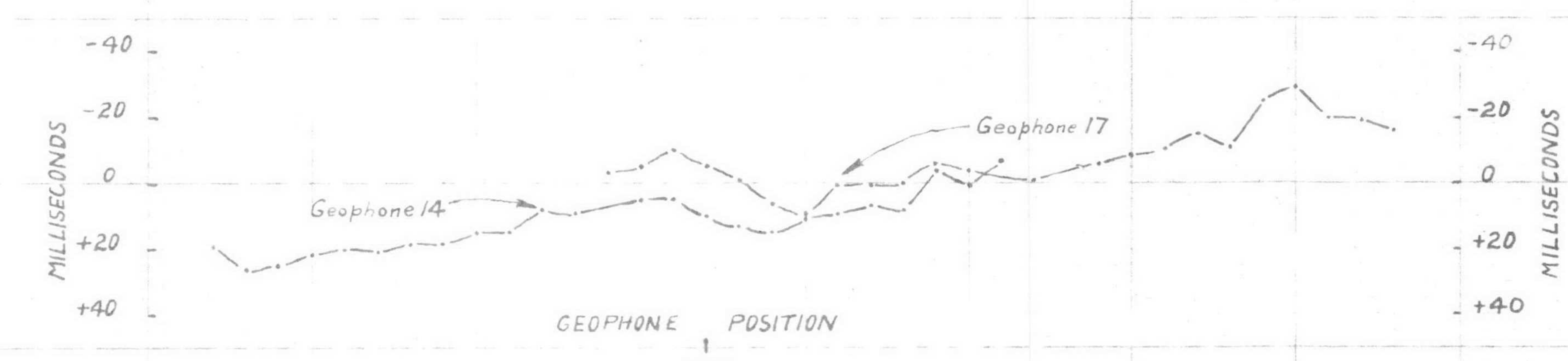
To Accompany Records 1959, No. 151



(a) POSITIONS OF GEOPHONES AND SHOT-POINTS



(b) VARIATION OF TIME OF REFRACTED RAY TO EACH GEOPHONE

CORRECTED FOR TIME TO TRAVEL GEOPHONE DISTANCE AT VELOCITY V_2 (14,300 FT. PER SEC.)

This is a measure of the depth to the V_2 layer.

Profiles correspond approximately if Geophone No. 14 (shot from SP18) is superimposed on Geophone No. 17 (shot from SP19).

Both Geophones receive Energy refracted from a Point almost Vertically beneath S.P. 11 representing an offset distance of 990 feet.

Calculated offset distance = 1012 feet for V_1 = 6000 ft. per sec.

COMBINED PROFILE is shown BELOW

POSITION on TRAVERSE relative to SP11

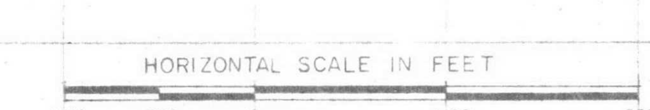
(c) PROFILE OF SEISMIC REFRACTOR

HAVING A VELOCITY OF 14300 FEET PER SECOND

For illustration Assumed V_1 = 6000 feet per second.
For other values of V_1 adjustment is necessary to conform with respective depths to V_2 layer shown above.

EXPERIMENTAL SEISMIC SURVEY, LATROBE VALLEY, VIC.

SEISMIC REFRACTION RESULTS TRAVERSE C



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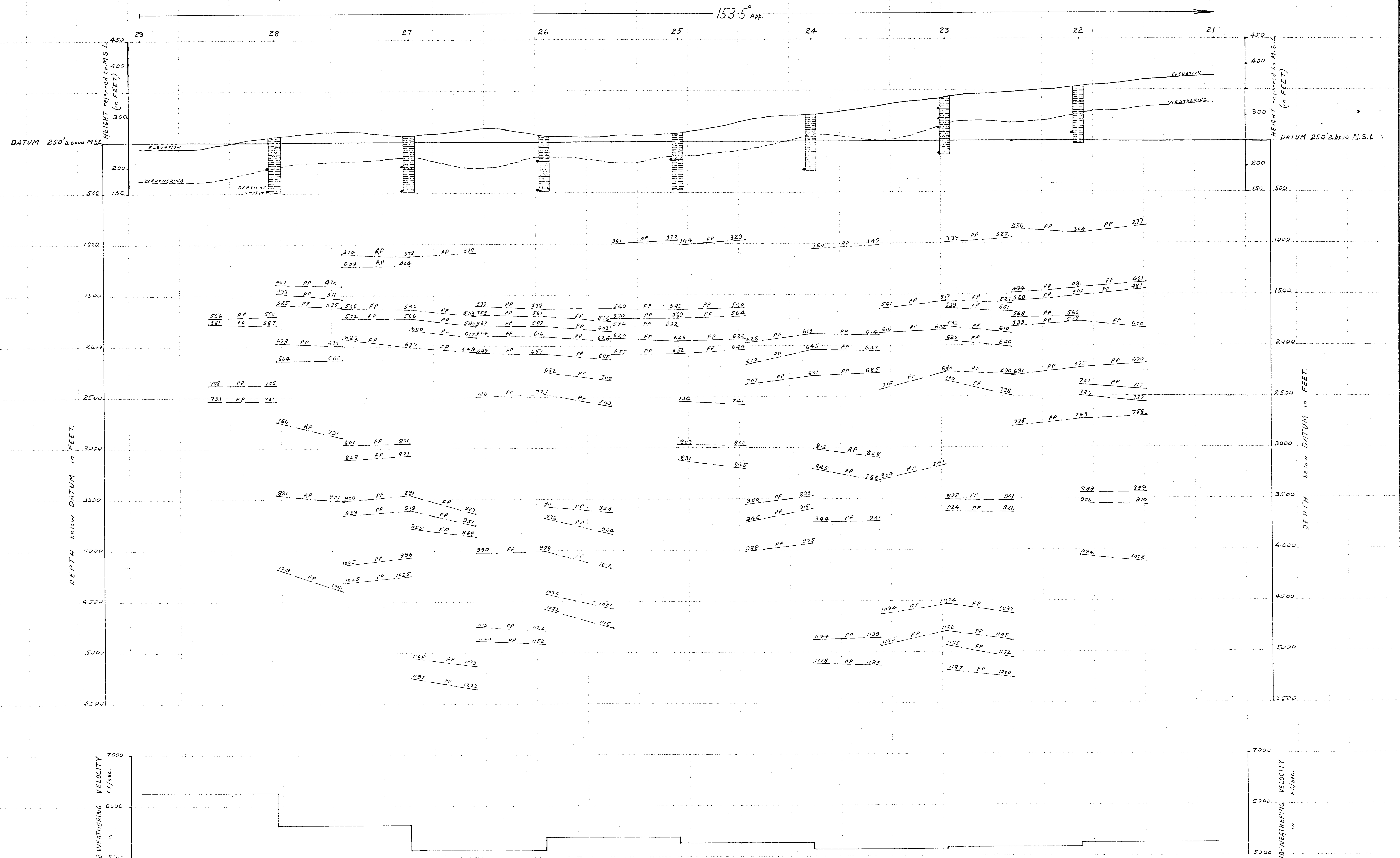


LEGEND

DRILL LOGS

Clay

Sand

CROSS - SECTION

Good Quality Reflection

Fair Quality Reflection

Poor Quality Reflection

Doubtful Quality Reflection

EXPERIMENTAL SEISMIC SURVEY, LATROBE VALLEY, VIC.

SEISMIC REFLECTION CROSS-SECTION TRAVERSE B

(MARYVALE)

UNMIGRATED CORRELATION SECTION

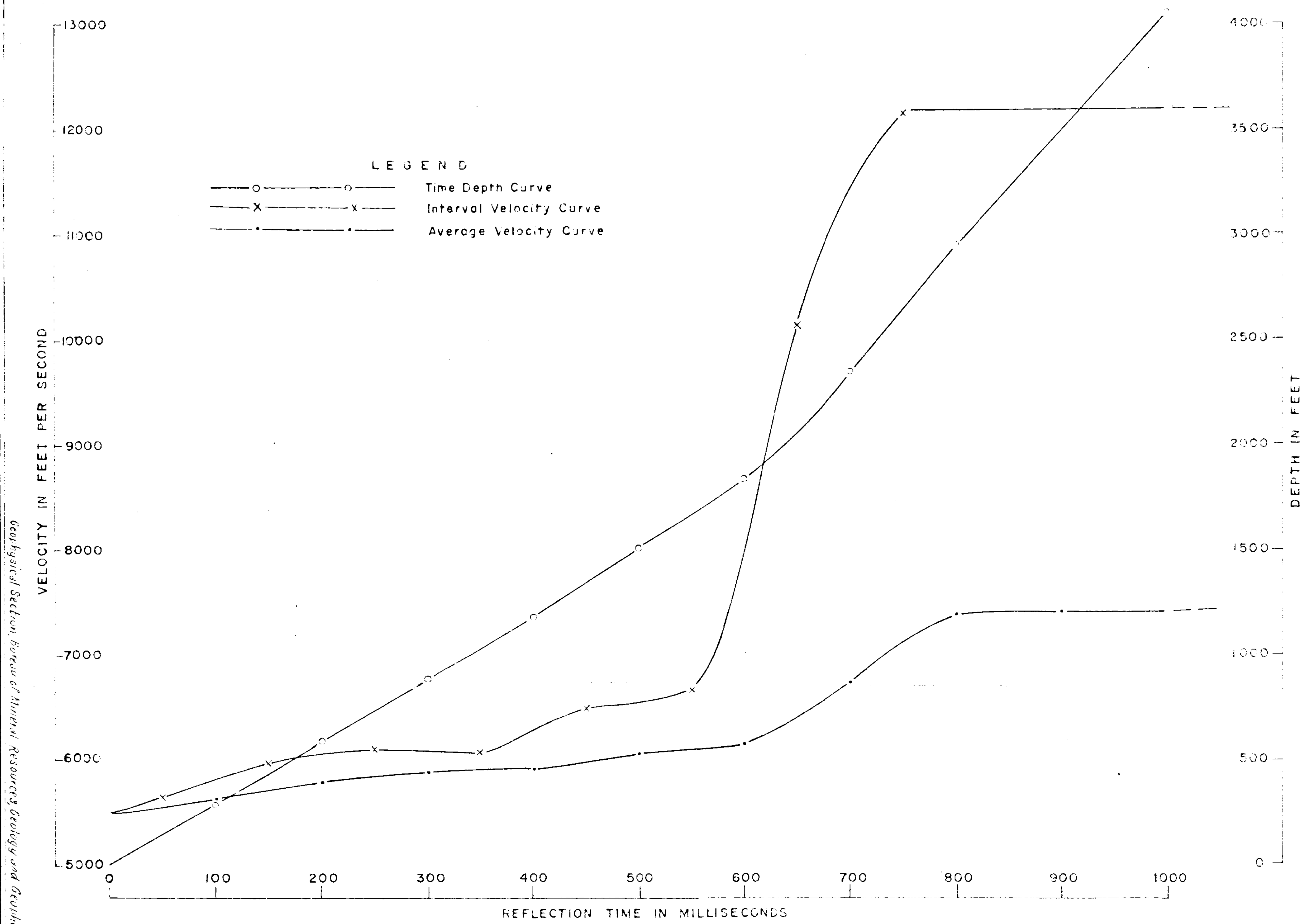
HORIZONTAL SCALE IN FEET

500 400 300 200 100 0 500 1000

Geophysical Branch, Bureau of Mineral Resources, Geology & Geophysics

G 93-63

To Accompany Records 1959, No. 151



EXPERIMENTAL SEISMIC SURVEY, LATROBE VALLEY, VICTORIA.

TIME DEPTH, INTERVAL VELOCITY AND AVERAGE VELOCITY CURVES.

PLATE 7

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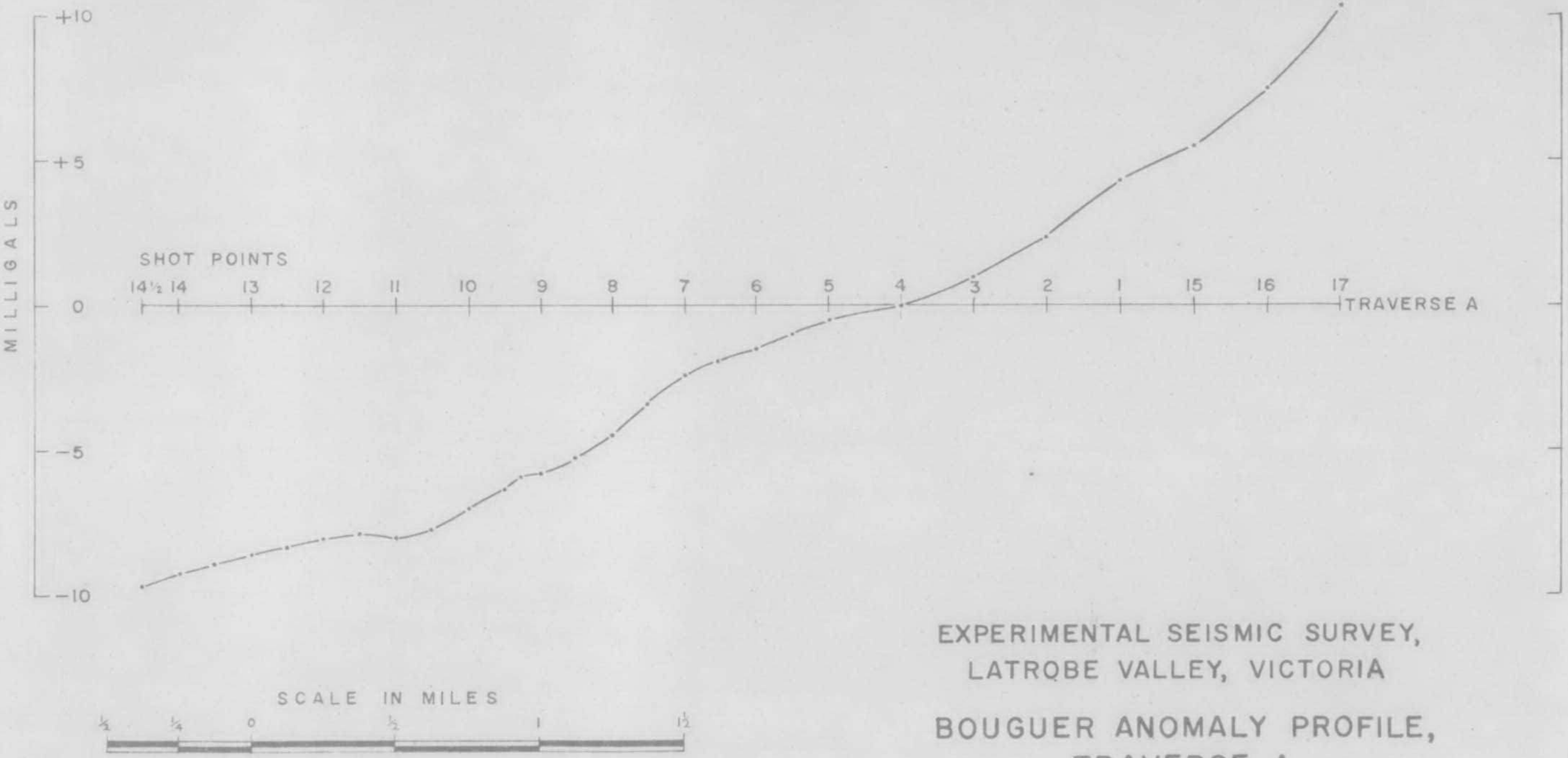

EXPERIMENTAL SEISMIC SURVEY,
LATROBE VALLEY, VICTORIA

BOUGUER ANOMALY PROFILE,
TRAVERSE A

PLATE 8

G 93-58

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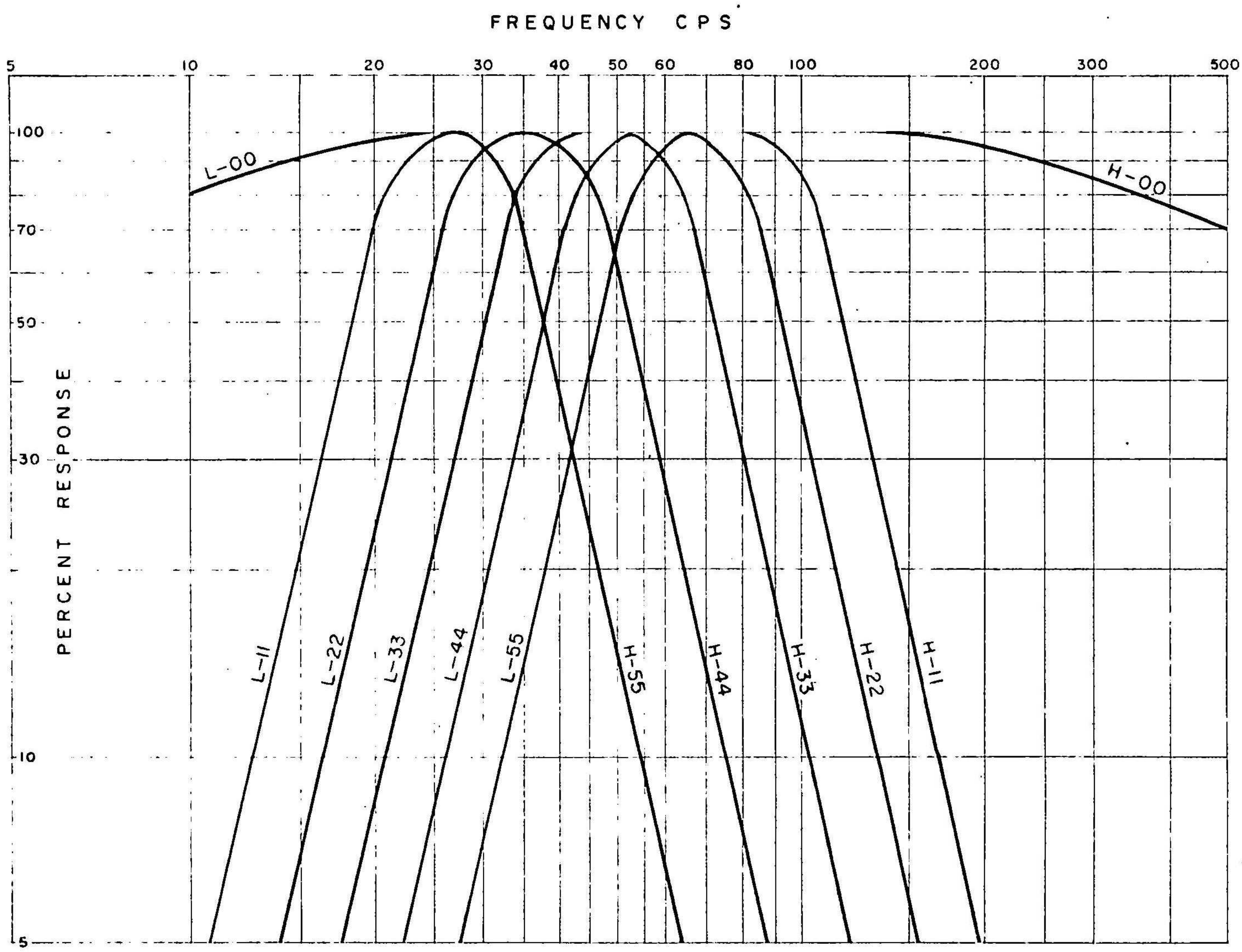
To Accompany Records 1959, No. 151



2 Sections low cut
2 Sections high cut

MODEL 621-I AMPLIFIER RESPONSE

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To accompany Records 1959, No 151