COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT No. 19

SEISMIC REFLECTION SURVEY, DARRIMAN, GIPPSLAND, VICTORIA.

By

M. J. Garrett

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ISSUED UNDER THE AUTHORITY OF SENATOR THE HON. W. H. SPOONER, M.M., MINISTER FOR NATIONAL DEVELOPMENT

1955

LIST OF REPORTS

1. Preliminary Report on the Geophysical Survey of the Collie Coal Basin - N.G. Chamberlain, 1948.
2. Observations on Stratigraphy and Palaeontology of Devonian, Western Portion of Kimberley Division, Western Australia - Curt Teichert, 1949.
3. Preliminary Report on Geology and Coal Resources of Oaklands-Coorabin Coalfield, New South Wales - E. K. Sturmfels, 1950.
4. Geology of the Nerrima Dome, Kimberley Division, Western Australia - D. J. Guppy, J. O. Cuthbert and A. W. Lindner, 1950.
5. Observations of Terrestrial Magnetism at Heard, Kerguelen and Macquarie Islands, 1947 - 1948 (Carried out in co-operation with the Australian National Antarctic Research Expedition, 1947 - 1948) - N. G. Chamberlain, 1952.
6. Geology of New Occidental, New Cobar and Chesney Mines, Cobar, New South Wales - C. J. Sullivan, 1951.
7. Mount Chalmers Copper and Gold Mine, Queensland - N. H. Fisher and H. B. Owen, 1952.
8. The Ashford Coal Province, New South Wales - H. B. Owen, G. M. Burton and L. W. Williams, 1954.
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10. Geologicial Reconnaissance of South-Western portion of Northern Territory - G. F. Joklik, 1952.
11. The Nelson Bore, South-Western Victoria; Micropalaeontology and Stratigraphical Succession - I. Crespin, 1954.
12. Stratigraphy and Micropalaeontology of the Marine Tertiary Rocks between Adelaide and Aldinga, South Australia - I. Crespin, 1954.
13. The Geology of Dampier Peninsula, Western Australia - R. O. Brunnschweiler.
14. A Provisional Isogonic Map of Australia and New Guinea, Showing Predicted Values for the Epoch 1955-5 - F. W. Wood and I. B. Everingham, 1953.
15. Progress Report on the Stratigraphy and Structure of the Carnarvon Basin, Western Australia - M. A. Condon, 1954.
16. Seismic Reflection Survey at Roma, Queensland - J. C. Dooley, 1954.
17. Mount Philp Iron Deposit, Queensland - E. K. Carter and J. H. Brooks, 1955.
18. Petrology and Petrography of Limestones from the Fitzroy Basin, Western Australia - J. J. E. Glover, 1955.
19. Seismic Reflection Survey, Darriman, Gippsland, Victoria - M. J. Garrett, 1955.
20. Review of Activities of the Commonwealth Micropalaeontological Laboratory, 1927-52 - I. Crespin.
21. Magnetic results from Heard Island, 1952 - L. N. Ingall, 1955.

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Secretary - H. G. Raggatt, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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ABSTRACT

A seismic reflection survey was carried out in the Parish of Darriman, Victoria. The survey was planned to investigate a gravity anomaly, which may be an indication of a structure favourable to the accumulation of oil or natural gas.

For the most part reflections were exceptionally good, and it was possible to trace one reflecting layer throughout most of the area.

Contouring showed the presence of an anticlinal structure, plunging to the east, but rising and broadening to the west. On the flat crest of the structure, there is probable closure in two places.

The thickness of the Tertiary sediments in the area may be a maximum of 6,000 feet, but may be only 3,000 feet on the crest of the structure and 4,000 feet on the flanks.

INTRODUCTION

The Darriman area is approximately 110 miles east-south-east of Melbourne and 17 miles north-east of Yarram in the Victorian Division of East Gippsland, (Plate 1). Oil was first noted in bores in East Gippsland, Victoria in 1924 (Boutakoff, 1951), but the main drilling activity in the area did not begin until some years later. Raggatt and Crespin (1943) record that more than 100 bores have been sunk in East Gippsland in the search for oil; only two of these, Darriman Nos. 3 and 4, are in the particular area covered by the present survey.

In 1949, the Robert H. Ray Company of Houston, Texas carried out a gravity survey on behalf of Lakes Oil Ltd. over an extensive portion of East Gippsland. The density of stations was greatest in the Lakes Entrance area and decreased to the west and south-west. The Parish of Darriman was the southernmost limit of this survey, and was surrounded by gravity traverses, though none actually crossed it. This work indicated an anomaly, which later work by the Bureau confirmed and showed in more detail. The Darriman area was reported by the contracting company to be favourable, with good possibilities.

During 1951, the Bureau covered a large area in East Gippsland by a semi-regional gravity survey, the results of which led to a detailed gravity survey of the Darriman area in 1952. In the semi-regional survey, the station interval was half-a-mile and traverses were confined to the highways and shire roads. When the survey was extended, the station interval remained the same, but additional traverses were laid out across country to give more complete coverage where detailed information was required.

These surveys carried out by the Bureau in 1951 and 1952 showed clearly the anomaly in the Parish of Darriman which had been indicated by the earlier Robert H. Ray survey. The anomaly was thought to be due to a gentle rise of the Jurassic strata which underlie the Tertiary sediments. It was calculated that there are 4,200 feet of Tertiary sediments over the crest of the rise, thickening to 4,700 feet on the flanks (Neumann, 1954).

Early in 1952, the Bureau carried out a seismic reflection survey immediately to the north of Lake Wellington, east of Sale (Vale, 1952), where gravity and aeromagnetic surveys had both shown an anomaly.

The survey under review was made early in 1954 and was planned to ascertain:-

(a) Whether a high in the Jurassic basement, as indicated by the gravity anomaly, may be associated with an anticlinal structure in the overlying Tertiary sediments.

(b) If the depth of sediments is of the order of 4,200 to 4,700 feet.

The area covered by the survey is in the Parish of Darriman and is bounded on the west by the South Gippsland Highway, on the south and east by the Giffard Road, and on the north by the Four Mile Creek Road, except where Traverses A and C extend across that road for about one and a half miles.

GEOLOGY

The area covered by the survey is one of low relief and is partly covered by sparse timber. It is bordered to the north-west by the South Gippsland Highlands and to the south-east by Bass Strait. The surface is entirely of sand, gravel and clay, and there are no hard rock outcrops. However, limestone of Tertiary age was encountered in some of the seismic shot holes near the South Gippsland Highway.

The geology of the coastal areas of East Gippsland is known mainly from the results of drilling. Two deep bores, Darriman Nos.3 and 4 were drilled on the borders of the area investigated (see Plate 2). These bores encountered sediments of Tertiary age. Neither of the bores has penetrated deeper than Janjukian marine sediments, and from observations in other bores in East Gippsland, it is assumed that the Janjukian sediments are underlain in turn by Anglesean marine and/or fresh water sediments and Jurassic sediments, above an igneous or metamorphic basement. The stratigraphic sequence in the East Gippsland Tertiary rocks has been developed by a study of cores from the large number of bores in the area, as well as from surface sections (Crespin, 1943). The sequence is as shown in Table 2, in which the series and stages are based on the report by Crespin (1943), as amended by Crespin (1953). No changes have been made in the table consequent on the report by Raggatt and Crespin (1952). Division of the section into the various stages was based mainly on the foraminifera.

The maximum known thickness of the Tertiary sediments is 3,930$^{\pm}$feet (Holland's Landing Bore), but the results of the regional gravity survey suggest that they may attain a greater thickness in the south-western portions of East Gippsland.

In the Lakes Entrance area the oil-bearing stratum was a glauconitic sandstone ranging up to 60 feet in thickness, and resting on a granite or metamorphic basement. This sandstone is the only reservoir rock so far known in the area. In the upper portion the oil impregnated only narrow, irregular bands (Thyer and Noakes, 1945) and most of the reservoir rock was impervious. The lower portion contained no oil, but had high porosity and permeability (Thyer, 1944). The glauconitic sandstone trends approximately parallel to the coast, but only as far south-west as Lake Wellington. The source rocks in Gippsland are not known (Boutakoff, 1951).

Major structural features in the Tertiary sediments near the Darriman area are the Baragwanath Anticline to the north-west, and the Won Wron Monocline. Knowledge of both of these structures has been developed from bore information. The Baragwanath Anticline is an asymmetric fold, dipping steeply on the northern flank; the southern flank dips gently, with a thickening of Tertiary sediments seawards. It plunges steeply to the east. The Won Wron Monocline trends south-west from the Baragwanath Anticline for more than 35 miles. It is situated to the west of the Darriman area and forms a major part of the southern flank of the South Gippsland Highlands. Eastwards, towards the coast, the surface is flat and is covered by Tertiary gravels (Thomas and Baragwanath, 1949).

FIELD WORK

The field party left Melbourne on 18th January, 1954 and returned on 15th April, 1954. The work of the party falls naturally into the following sections.

Surveying. A surveyor and two assistants were supplied by the Department of the Interior. The traverses were laid out using theodolite and chain. Elevations above sea level of all shot points and geophone stations were read. A plan of the traverses, together with the surface contours is shown on Plate 2.

Drilling. The drill - a Failing "750" type - and drilling staff were supplied by the Petroleum Technology Section of the Bureau. Two water tenders were used to carry water for drilling. At the start of the survey, one shift per day was worked by a crew of two.

Drilling on the area at first presented a problem. A surface clay ranging in thickness from 5 to 30 feet covered a considerable thickness of fine, loose sand. During the first week of drilling, water only was used as the drilling fluid. This would not raise the sand cuttings from the hole, however, and there was danger of the pipe becoming blocked in the hole. To overcome this problem, bentonite mud was used.

This served two purposes - the increased specific gravity of the fluid raised the cuttings faster, and the mud conditioned the walls of the hole.

To increase the drilling rate, a second shift was worked from 17th February to 19th March. The day shift was worked by a crew of three, and the evening shift by a crew of two.

All holes finished in the sand, except a few along Traverse F (along the South Gippsland Highway). In these holes, hard bands were encountered at depths of about 140 feet, and were described as hard gravel and boulders. Small pieces of rock were blown out of one or two of these holes and were identified as limestones of Tertiary age. Circulation was lost in several holes along this traverse, and drilling was very difficult.

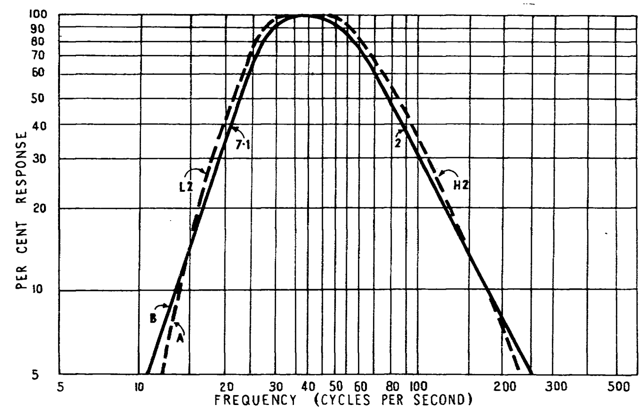
For most of the survey shot holes of 4.3/4 inches diameter were drilled, but on 11th March, the hole size was reduced to 3.7/8 inches diameter.

Shot Recording. For the first part of the survey, a set of 24-channel reflection equipment manufactured by the Technical Instrument Company was used. This was returned to Melbourne on 22nd March and replaced by 24-channel reflection equipment manufactured by the Swedish Electrical Prospecting Company. Both sets of equipment were truck-mounted.

The conventional split-spread method of shooting was used. Traverses were surveyed with eleven geophone stations between shot points. The standard station interval was 110 feet, (i.e., one quarter mile between shot points.), but this was altered in certain instances, e.g., when it became necessary that a shot point should fall in a certain position, such as within a road reserve intersecting the traverse line, or to avoid natural features such as creeks. Geophones were placed at twelve stations to each side of the shot point, with a double interval between the end pairs furthest from the shot point. That is to say, no geophones were placed at the holes adjacent to the one being shot. This avoided time irregularities that might arise due to shattering in the vicinity of a hole that had already been shot.

The use of multiple geophones - i.e., more than one geophone at each station recording on the same channel - so improved the quality of reflections that this procedure was adopted for the whole area. When using the T.I.C. equipment, four geophones recorded on each channel. They were connected as two paralleled series pairs, set out in line of traverse with a five feet interval between geophones at each station. When using the Swedish equipment, two geophones recorded on each channel. These were set out in line of traverse with ten feet separation. The only reason for reducing the number of geophones at each station with the change of equipment was that sufficient geophones were not available.

With the T.I.C. equipment, the amplifier filter setting used was L2, H2, giving a maximum response at 30-50 cycles per second. With the Swedish equipment, the amplifier filter setting used was 27, giving a maximum response at 35 to 45 cycles per second (see Text Fig.1).



Text Fig.1 : Filter response curves.
Curve A - Filter position L2 H2, T.I.C. amplifier,band pass type 521.
Curve B - Filter position 27, A.B.E.M. amplifier, type 900.

It was not usual to shoot a mixed record at each shot point, in addition to the single record. It was only when reflection quality on the single record was poor that a mixed record was taken. Presuppression of amplifier gains was used to reduce the effect of wind and noise and to give sharp first refraction breaks. Both units are equipped with Automatic Volume Control.

Table 1 shows which set of equipment was used at the various shot points.

The full field recording unit consisted of a recording truck, a shooting truck and cable-carrying utility. These were manned by an observer, shooter and (for the most part) three assistants.

Wherever possible, traverses were laid out within the road reserves. Where it was necessary to lay traverses across country, the small size of paddocks and the consequent large number of fences to be crossed made field work difficult with truck-mounted equipment. The co-operation of the land owners in the area was an important factor on such traverses, and was appreciated by the field party. The proportion of cleared grazing land to uncleared timbered land was approximately one to one, but the uncleared land is not unduly difficult of access.

COMPUTING METHODS.

In the final reduction of results, both continuous correlation and dip-plotting methods were used. In both methods, reflections are picked on a record from each shot point. The average times for the reflections to return to geophone stations 1 and 2, 12 and 13, and 23 and 24 were marked on the record. The least square value of the time versus distance slope for each reflection over ten station intervals was determined using a specially constructed circular slide rule. Each reflection was graded, the system used being to assign a grade (Good, Fair or Poor) for both certainty of reflections and accuracy and an RP grade to indicate reflections of doubtful certainty. (Gaby, 1949). To the recorded time of any reflection however, two corrections must be applied.

Firstly, a correction for the travel path in the low velocity or "weathered" layer must be calculated. In the Darriman area, the velocity in the "weathered" layer was 1,850 ft/sec. The velocity in the material immediately below the "weathered" layer, i.e., the elevation velocity, was 5,800 ft/sec. The thickness of the weathered layer is shown at the top of each cross section, and also as a contour map on Plate 3. This map and the surface contour map (Plate 2) show close similarity of shape and position of contours, i.e., the thickness of the weathered layer is greatest in the hilly areas and least in the valleys and coastal areas, thus suggesting a close relationship between the base of the weathered layer and ground-water level. It is of interest to note that the best shooting depth over the whole area was below sea level, and in many cases the shot position was as much as 50 feet below the base of the low velocity layer. No explanation in terms of velocity stratification was found to explain this.

Secondly, an elevation correction must be applied to reduce travel times to a flat datum plane. The datum level chosen was fifty feet below sea level.

Weathering and elevation corrections were calculated by the up-hole correction method. From the time of the first refraction break on the geophone nearest to the shot point and the depth of shot, the up-hole time under the nearest geophone was calculated. This is the up-hole time that would be recorded were the shot fired at the same level as, but directly under, the geophone. A chart was prepared to avoid the small arithmetic calculation for each record. The travel times from shot point to datum and from datum to equivalent shot position under the geophone were calculated by dividing these distances by the elevation velocity. The sum of these three gave a total correction to datum at the geophone closest to the shot point.

To plot the dip section by the method of least squares, the time in the weathering layer (t_W) at each geophone station must be known. To do this, the first refraction breaks recorded on each spread from both shot points were plotted relative to the same axes. The slope of the best line through these points was assumed to be the true sub-weathering velocity under this spread. Variations of points from this line were assumed to be due to variations in the thickness of the weathered layer under the geophone at which this time was recorded. The absolute value of the weathering correction was found by the up-hole method for the geophone stations adjacent to each shot point, and the relative values for every station found by the graphical method were corrected to fit these.

The slope of each reflection across the record is determined by three factors:-

(a) the dip of the reflector,

(b) an effect due to elevation and thickness of the weathered layer,

(c) spread correction, due to the increasing reflection path to each geophone.

If a reflection is picked across the full record (i.e., across 24 traces) and the step-out of the reflection on one side of the record subtracted from that of the same reflection on the other side of the record, the dip effect is cancelled out, and we are left with the spread correction for that reflection time. The large number of points obtained and plotted are averaged to the best T $-\Delta t$ curve. From this curve it is possible to derive:-

(i) a velocity distribution,

(ii) a curve of reflection time versus depth,

(iii) a set of curves relating reflection step-out, reflection time, and dip of the reflector.

In the correlation plotting, "end" and "centre" times for each reflection were used. Weathering and elevation corrections were calculated by the up-hole method. A spread correction was subtracted from times for the furthest geophone. Times were plotted with no "migration" of depth points.

In the dip-plotting method, the least square slope of the weathering and elevation correction across the record was subtracted from the reflection step-out, and a spread correction applied. The dip value corresponding to this corrected step-out was determined, and each reflection plotted. The method ensured that depth points were "migrated", so that the normal to the reflector passed through the shot-point position.

Cross-sections of the traverses obtained by both continuous correlation and dip-plotting methods are shown in Plates 4 to 11, inclusive.

DISCUSSION OF RESULTS.

This is carried out in three sections:-

(a) a discussion of individual traverses, in which no attempt is made to correlate results,

(b) a correlation of the results obtained from individual traverses, as described in (a),

(c) a discussion of the resulting contour map and a co-ordination of results.

Individual Traverses.

Traverse A. (Plate 4).

This traverse extended across the eastern end of the gravity anomaly, trending approximately north-south. Reflections were extremely good north of S.P.8, and this part of the traverse crosses the best reflecting section in the area. South of S.P.4 reflections were poor; dips are steep on this section of the traverse, and these holes were shot before the full value of the multiple geophone arrangement was realised. However, continuous correlation was possible along the full length of the traverse.

The plotted cross-section shows that the traverse crosses an asymmetrical anticlinal fold, the crest of which is approximately under S.P.5. The continuous reflecting horizon dips gently to the north at about 3°, and rather steeply to the south at about 12°. At the southern end of the traverse, the south dips appear to be decreasing.

Traverse B. (Plate 5).

This was an east-west traverse along the length of the nosing of the gravity contours. It is on the north flank of the structure revealed by this seismic survey.

The quality of reflections was good along the whole traverse. Continuous correlation was possible, except over the last two shot points at the eastern end. The reflecting horizon was continued past S.P.44 by the construction of a "phantom" horizon.

At S.P.51 there is a serious mis-tie of the continuous reflection with records from adjoining shot points. In this section however, the reflection picked is extremely good, and continuous over three cycles. There can be no doubt that the correct leg of the reflection has been followed from S.P.50 across S.P.51 to S.P.52, despite the poor time-tie. It will be noted that the error is present for all reflections picked at that shot point, and a positive correction to reflection times is indicated. This condition has been noted on several shots during this survey and it is believed that the error is an error of the shot-instant break. It was noted, for example, on records at S.P.41 on this same traverse, where there was a serious mis-tie of reflections. In this instance, the record picked for reflections was checked against others shot at the same point, and a correction to the shot-instant break applied. In the other instance (at S.P.51) only one shot was recorded and a similar comparison of records was not possible.

Along most of the traverse, very gentle east dip was recorded. There is a steep monoclinal flexure between S.P's.119 and 122. The reflecting horizon drops sharply to the east and has a change in level of 440 feet. Under S.P.41 west dips were recorded, and a small "high" is shown in the continuous reflecting horizon under S.P.42.

Traverse C. (Plate 6).

This was a north-south traverse, parallel to Traverse A, and like it, crossing the gravity anomaly. It is situated 1.1/4 miles west of Traverse A.

Reflection quality was fair to good along the traverse, and continuous correlation was possible.

The cross-section shows that the traverse crossed an anticlinal flexure, somewhat asymmetrical, with the crest of the fold between S.P's.16 and 17. North dip was recorded over only three shot points. (The traverse was not extended as far to the north as was Traverse A). The reflecting horizon dips to the north at about 6°, i.e., steeper than on Traverse A. On the other hand, south dip on the southern flank of the fold was shallower than on Traverse A, being about 8°. The crest of the fold in the continuous reflector is 1,720 feet below sea level.

Traverse D. (Plate 7).

This traverse was laid out along the Giffard-Seaspray Road, for a distance of 5.1/2 miles from where this road leaves the South Gippsland Highway. Its direction is approximately east-west. For reasons of accessibility, the traverse was laid within the road reserve. This necessitated several bends in the traverse but these are not more than a few degrees.

Reflections along the traverse were good and continuous correlation was possible.

The following features may be noted on the cross-section:-

(i) Steep east dips at the eastern end of the traverse, although they flatten out under S.P.1. This zone of east dip extends from S.P.96 to the eastern end of the traverse. The average dip over 1.3/4 miles is about 8.1/2°.

(ii) A monoclinal flexure dipping sharply to the west between S.P's 83 and 73 at the western end of the traverse. The change in level is about 330 feet.

(iii) Between these two features the continuous reflector is fairly flat. However, there is a gentle "high" in the section under S.P.91 with a relief of about 100 feet.

(iv) There are again some mis-ties along the continuous reflector which required checking. A rather serious one exists from S.P.21 across S.P.22 to S.P.23. A comparison of the adjacent records, considering the reflection character, showed that the correct leg of the reflection had been followed across this doubtful point. A correction to the shot-instant break should be made. Other mis-ties - from S.P.84 across S.P.85 to S.P.86, and from S.P.92 across S.P.93 to S.P.94 - were checked in a similar manner.

Traverse E. (Plate 8).

This was laid out as an east-west traverse, parallel to, and 1.1/4 miles north of, Traverse B, to intersect Traverse A near S.P.30. Recordings were made at only two shot points - S.P's.32 and 33 - and the traverse was neglected in favour of others on the more important portion of the structure.

Reflections obtained from the two shot points were numerous and extremely good. Slight east dip was recorded.

The only section plotted was the continuous correlation section. A dip section would not have been of any value, as dip sections in this area were plotted primarily to obtain information on horizontal displacement.

Traverse F. (Plate 9).

This was a traverse along the South Gippsland Highway. It extended from the Giffard-Seaspray road in the south to a point two miles past the Darriman Post Office. Its direction is approximately north-east/south-west.

Along this traverse, maximum variation in reflection quality was observed. From S.P.62 south-west to S.P.56, reflections were very good and continuous correlation was possible. South-west from S.P.56 it was not possible to follow one reflection continuously. There are two main "gaps" in the reflection information along this section of the traverse, namely at S.P's.55, 64, 65 and 66 and at S.P.69. This statement may appear incorrect, in that reflections are plotted on the cross-section as having been recorded at these shot points. However, reference to the grade of the reflections at these shot points shows that none have been given better than a P grading for accuracy. In the Darriman area - generally a good reflecting area - considerable errors may be made due to misinterpretation when only low quality reflections are recorded over several consecutive shot points, as sharp changes of dip are likely and were recorded along some traverses.

A continuous reflecting horizon was followed along that section of the traverse where continuous correlation was possible. South-west from S.P.56 a "phantom" horizon was constructed from the dip section. There was a considerable mis-tie at S.P.73 on the first "phantom" horizon. This was corrected by distributing the error over the sections of doubtful or no information.

The shot at S.P.72 recorded steep north-east dip on one half of the record, and south-west dip on the other side. From S.P.73 (to the south-west) north-east dip was recorded, and from S.P.71 (to the north-east) south-west dip was recorded. A synclinal trough, with steep dips on the north flank, is thus recorded under S.P.72. When the correlation section was plotted (with no migration of depth points) an attempt was made to correlate across this portion of the traverse. The dip section shows the inaccuracy that such a method involves. The depth points for these reflections of different dip at S.P.72 are migrated in opposite directions, leaving a gap of over 1,000 feet in the cross-section. In constructing the "phantom" horizon, this gap was crossed by an even smoothing of dip, at intervals of 110 feet.

The main features shown on the cross-section are:-

(i) North-east dip from S.P.56 to S.P.62.

(ii) South-west dip south from S.P.56, but there are reversals of dip at S.P.65 and S.P.67.

(iii) Steep south-west dips at S.P.71 and S.P.72. The change on level of the "phantom" horizon is 440 feet at this point.

(iv) North-east dips at S.P.73.

Traverse G. (Plate 10).

This was a north-south traverse parallel to Traverses A and C and located about 1.1/2 miles west of Traverse C.

Except at S.P.109, where only one reflection of grade RP was recorded, reflections were good and continuous correlation was possible. The continuous reflecting horizon was constructed from each end, and joined across the gap at S.P.109 by averaging the dips on each side to give a smooth horizon.

The following features are of note:-

(i) North dips were recorded north from S.P.108, although they flatten out at the northern end of the traverse.

(ii) Two distinct "highs", one under S.P.108 and the other under S.P.113. The crest of the northern "high" is 1,740 ft. below sea level on the continuous reflector. The trough between the two "highs" is broad and shallow.

(iii) Very steep dips from S.P's.115 and 116 (an average dip of about 18°).

(iv) A time mis-tie from S.P.112 across S.P.113 to S.P.114 on the continuous reflector. Only one usable record was obtained, but a comparison of adjacent records, considering reflection character, prevented any error in following the continuous reflector.

Traverse I. (Plate 11).

This was a north-south traverse joining Traverses B and D, and parallel to Traverses A, C and G. It was located one mile west of Traverse G.

With the exception of S.P.128, reflections were good and continuous correlation possible. Even at S.P.128 where only one RP reflection was recorded there is little doubt that this is the continuous reflection.

The section shows:-

(i) A monoclinal flexure dropping sharply to the south between S.P's.121 and 125. The change in elevation is 330 feet.

(ii) South of this, an anticlinal structure was crossed, the crest underlying S.P.129. South dip was recorded over only three shot points.

Correlation of Cross-Sections.

A study of the cross-sections reveals the following features:-

(i) A zone of good reflections, which is about 300 milliseconds (or 1,000 feet) through, on most traverses. It ranges from about 250 milliseconds (850 feet) to 400 milliseconds (1,400 feet) at different places. The continuous reflector is at the top of this zone.

(ii) Regarding the thickness of sediments, the following details are noted on the cross-sections:-

Traverse A. At the northern end of the traverse, reflections were recorded continuously to 6,000 feet. At the southern end of the traverse, reflections were poor to a maximum depth of 4,000 feet.

Traverse B. There were no reflections deeper than 3,000 feet, except at S.P's.104 and 41 where they were recorded to 6,000 feet.

Traverse C. Only a few PP and RP reflections were recorded below 3,500 feet.

Traverse D. Good grade reflections were usually above 3,000 feet except at the eastern end of the traverse where they were recorded to 4,000 feet. The deepest reflections on this traverse were to 5,000 feet at S.P.89.

Traverse E. Reflections were recorded throughout this section to 6,000 feet.

Traverse F. Reflections were generally above 3,000 feet, except at the northern end of the traverse where they were recorded down to 5,500 feet. These were of low quality and were possibly multiple reflections.

Traverse G. Generally, reflections were above 3,000 feet, but were recorded down to 5,500 feet at S.P.114.

Traverse I. Generally, reflections were above 3,000 feet; the deepest recorded was at 4,500 feet.

From this information it is possible to make the following deductions:-

(a) The total thickness of Tertiary sediments may be a maximum of 6,000 feet. In some parts of the traverses, reflections were recorded throughout the section to this depth.

(b) There may be only 3,000 feet of sediments on the crest of the structure and about 4,000 feet on the flanks. This takes into account the possibility that reflections recorded below 3,000 or 4,000 feet may be either multiples or fortuitous line-ups not due to reflected energy.

The above deductions do not consider the possibility that some of the reflections may be coming from within the Jurassic rocks. If they are, it would follow that the Jurassic rocks are generally conformable with the overlying Tertiary rocks, except for the zones of steep dip in the Tertiary rocks and which are considered to be associated with faulting in the Jurassic rocks.

There is no general evidence that the deep recorded reflections are multiples. The only positive evidence of recording multiples is at the northern end of Traverse F from S.P.51 to S.P.61. Here there are two zones of reflections, the lower zone having approximately twice the dip and twice the reflection time of the upper zone. As there is no other evidence of an unconformity in the section, this effect may be taken as evidence of multiple reflections.

No refraction traverses were shot in the area, though such a method would probably have given a good estimate of thickness of the Tertiary sediments.

Depth Contour Map.

The survey information obtained by plotting cross-sections was co-ordinated for easy inspection as a depth contour map (Plate 12). The contours were based on the surface of a continuous reflecting horizon, except along portion of Traverse F where they are based on the surface of a constructed "phantom" horizon.

The structural features that are shown by the contour map may be enumerated as follows:-

(i) The relationship between topography and structure is shown on the cross-sections, and can also be seen by comparing the structure contour map (Plate 12) with the surface contour map (Plate 2). This relationship is striking over the whole area, especially if we disregard the effect on topography of the creek which crosses Traverse B at S.P.49 and Traverse D at S.P.98. The relationship between topography and structure is a common feature in Tertiary sediments in Gippsland (Thomas and Baragwanath, 1950).

(ii) Two closed structural "highs" separated by a narrow shallow trough. The north-eastern structure has closure of less than 50 feet, within the limits of accuracy of the method. This structure lies within the area mapped on the continuous reflector. The south-western structure has closure of over 100 feet, but the information in this part of the area is poor. The closed 1,700 feet contour was based on a constructed "phantom" horizon along Traverse F. Along this horizon, a large mis-tie has to be distributed after the original construction of a "phantom".

(iii) Steep south dips were recorded along the southern edge of these structures. They are as high as 21°.

(iv) Zones of steep dip were recorded on other traverses. These are the monoclinal flexures referred to in the discussion of individual traverses. The number of traverses laid out over these zones was not sufficient to delineate the extent and strike of these features, as was possible in the case of (iii) above. The conclusion has been drawn that these are a result of post-Tertiary faulting in the Jurassic sediments. The incompetence of the Tertiary sediments has resulted in their being deformed without fracturing - a common feature in Tertiary Brown Coal Measures of the Latrobe Valley. The fault pattern is shown on Plate 13.

(v) Though the survey did not extend as far north as Darriman No.3 bore, some assumptions are made about the position of structure contours in its vicinity. It is assumed that the 1,900, 2,000, 2,100 and 2,200 feet contours swing around (in a similar manner to the gravity contours) to enclose a structurally low trough in the northern section of the Parish of Darriman. It is estimated that the 2,050 ft. contour would pass through the Darriman No.3 bore, that is, at this bore the continuous reflecting borizon is at a depth of 2,050 feet below sea level. Table 3 shows that the top of the Janjukian stage was approximately 930 feet below sea level in this bore. This is approximate only, as the elevation of the bore is not accurately known, but it was assumed to be 150 feet above sea level. It is suggested that the continuous reflecting horizon is at, or near, the top of the Anglesean stage. This gives to the Janjukian stage a thickness of approximately 1,120 feet at this point. In the previous seismic survey to the north of Lake Wellington, correlation was attempted between bores at Holland's Landing and Lake Kakydra, and it was suggested that the continuous reflection returned from either the top of the Jurassic rocks or the top of the Anglesean stage. (Vale, 1952).

The significance of the zone of good reflections referred to when discussing the correlation of cross-sections is that these reflections would be wholly within the Anglesean, and the zone may possibly represent the whole of this stage. On other assumptions, viz. that all reflections come from within the Tertiary rocks and that the Anglesean stage rests on the Jurassic rocks, there would be at least 2,000 feet of sediments between the bottom of the Janjukian and the top of the Jurassic sediments.

CONCLUSIONS

The following conclusions are drawn from the results of the seismic survey:-

1. There is an anticlinal structure which plunges to the east and rises and broadens to the west.

2. On the crest of the structure there is probable closure in two places.

3. The thickness of the Tertiary sediments may be a maximum of 6,000 feet, but may be only 3,000 feet on the crest of the structure and 4,000 feet on the flanks.

4. The anticlinal structure in the Tertiary sediments is associated with post-Tertiary faulting in the underlying Jurassic rocks.

5. There is insufficient evidence at present to comment on the possibility of the occurrence of oil or gas, but drilling is desirable for the following reasons:-

   (i) To provide information on the stratigraphy of the Tertiary and underlying sediments.

   (ii) To determine the physical characteristics of the rocks.

   (iii) To give accurate control to the interpretation of the seismic survey already made and any others that may be made.

6. The number and locations of the drill holes should be determined only after consideration of the results of the seismic survey and all geological information available at present and that would become available during any drilling campaign.

7. After drilling, further seismic work might be necessary if:-

   (i) More detailed information is required to locate the site of a second bore accurately, up or down dip relative to the first, or

   (ii) the results of the drilling are sufficiently encouraging to warrant a search in the adjacent coastal areas.

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TABLE 1

EQUIPMENT USED AT THE VARIOUS SHOT POINTS

Traverse	Shot Points	Equipment Used
A	1 to 8, 26 to 30	T.I.C.
B	8 to 13, 39 to 42, 49 to 52, 104 and 105	T.I.C.
	43 to 46, 118 to 122, 132, 133 and 57	A.B.E.M.
C	13 to 20 and 25	T.I.C.
D	1, 20 to 24, 73, 82 to 84, 94 to 99	T.I.C.
	85 to 93	A.B.E.M.
E	32 and 33	T.I.C.
F	55 to 73 excluding 67	T.I.C.
	67	A.B.E.M.
G	105, 107 to 114	T.I.C.
	100 to 102, 106, 115 and 116	A.B.E.M.
I	121, 124 to 131 and 89	A.B.E.M.

TABLE 2

STRATIGRAPHY OF THE TERTIARY SECTION IN EAST GIPPSLAND ø

Series	Stage	Sub-Stage	Formation
Lower Pliocene	Kalimnan		Jemmy's Point
Upper Miocene	Mitchellian		
Lower Miocene	Balcombian	Bairnsdale	Gippsland Limestone
		Batesford	
*		Longford	
Upper Eocene	Janjukian		Lakes Entrance
Middle Eocene	Anglesean		Yallourn

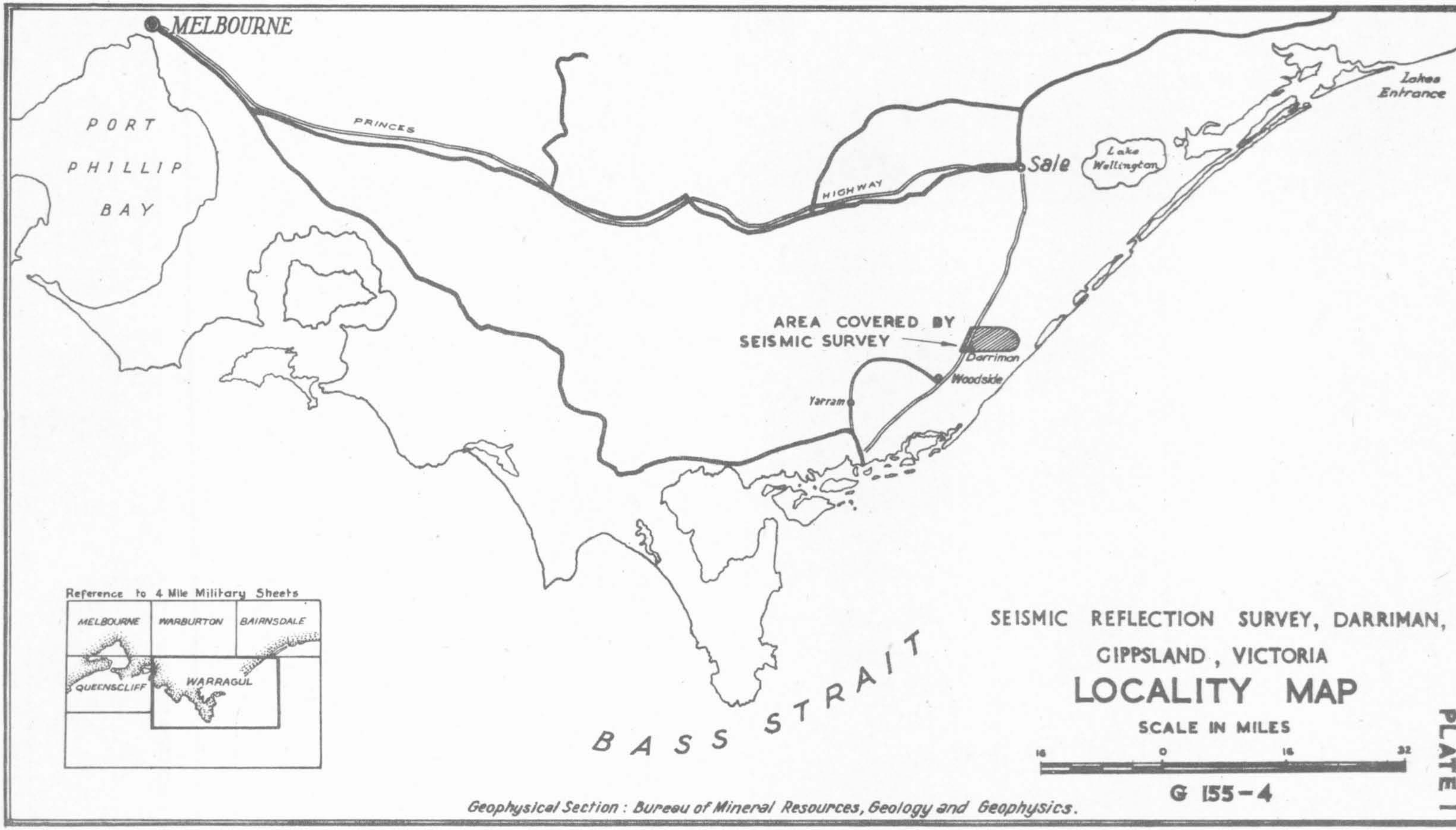
ø Crespin (1943) as amended by Crespin (1953).
* Marine Oligocene is almost completely absent in Australia (Crespin, 1953).

TABLE 3

LIMITING DEPTHS AND THICKNESSES OF STRATIGRAPHIC STAGES IN THE DARRIMAN BORES ≠

Stage	Sub-Stage	Darriman No.3	Darriman No.4
Kalimnan		62'-88'(26')	210'-410'(200')
Mitchellian		88'-169'(81')	420'-565'(145')
Balcombian	Bairnsdale	179'-289'(110')	575'-1175'(600')
	Batesford	299'-559'(260')	1180'-1245'(65'+)
	Longford	569'-1069'(500')	
Janjukian		1079'-1207'(128'+)	

≠ Crespin (1943).



SEISMIC REFLECTION SURVEY, DARRIMAN, GIPPSLAND, VICTORIA

LOCALITY MAP

G 155-4

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PLATE I

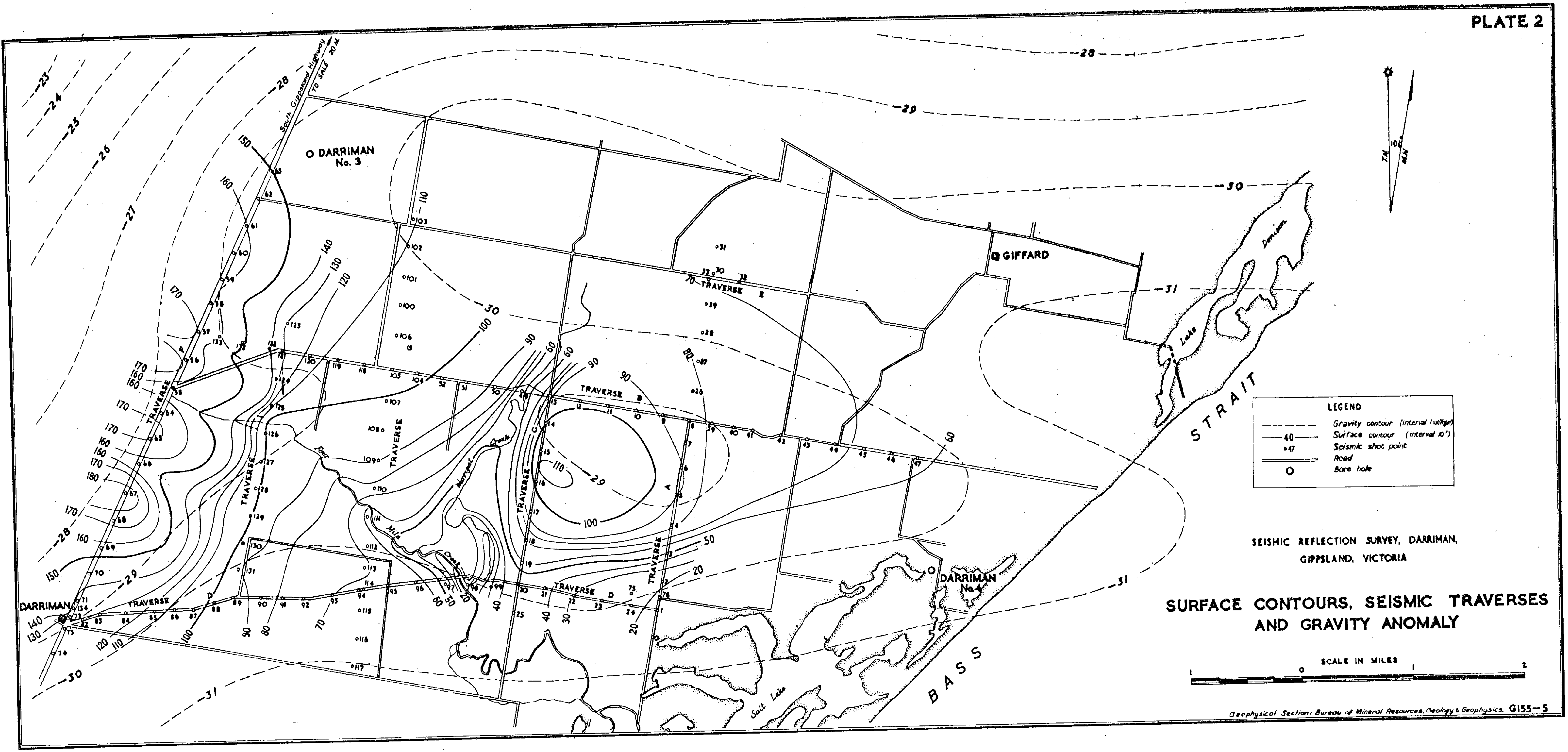
PLATE 2
SURFACE CONTOURS, SEISMIC TRAVERSES AND GRAVITY ANOMALY
SEISMIC REFLECTION SURVEY, DARRIMAN, GIPPSLAND, VICTORIA
LEGEND
Gravity contour (interval 1 milligal)
Surface contour (interval 10')
Seismic shot point
Road
Bore hole
SCALE IN MILES
1 0 1 2
T.N.
M.N.
10°
DARRIMAN No. 3
DARRIMAN No. 4
DARRIMAN
GIFFARD
South Gippsland Highway
TO SALE 20 M.
TRAVERSE A
TRAVERSE B
TRAVERSE C
TRAVERSE D
TRAVERSE E
TRAVERSE F
TRAVERSE G
Four Mile Creek
Merriman Creek
Lake Denison
Salt Lake
BASS STRAIT
Geophysical Section: Bureau of Mineral Resources, Geology & Geophysics. G155-5

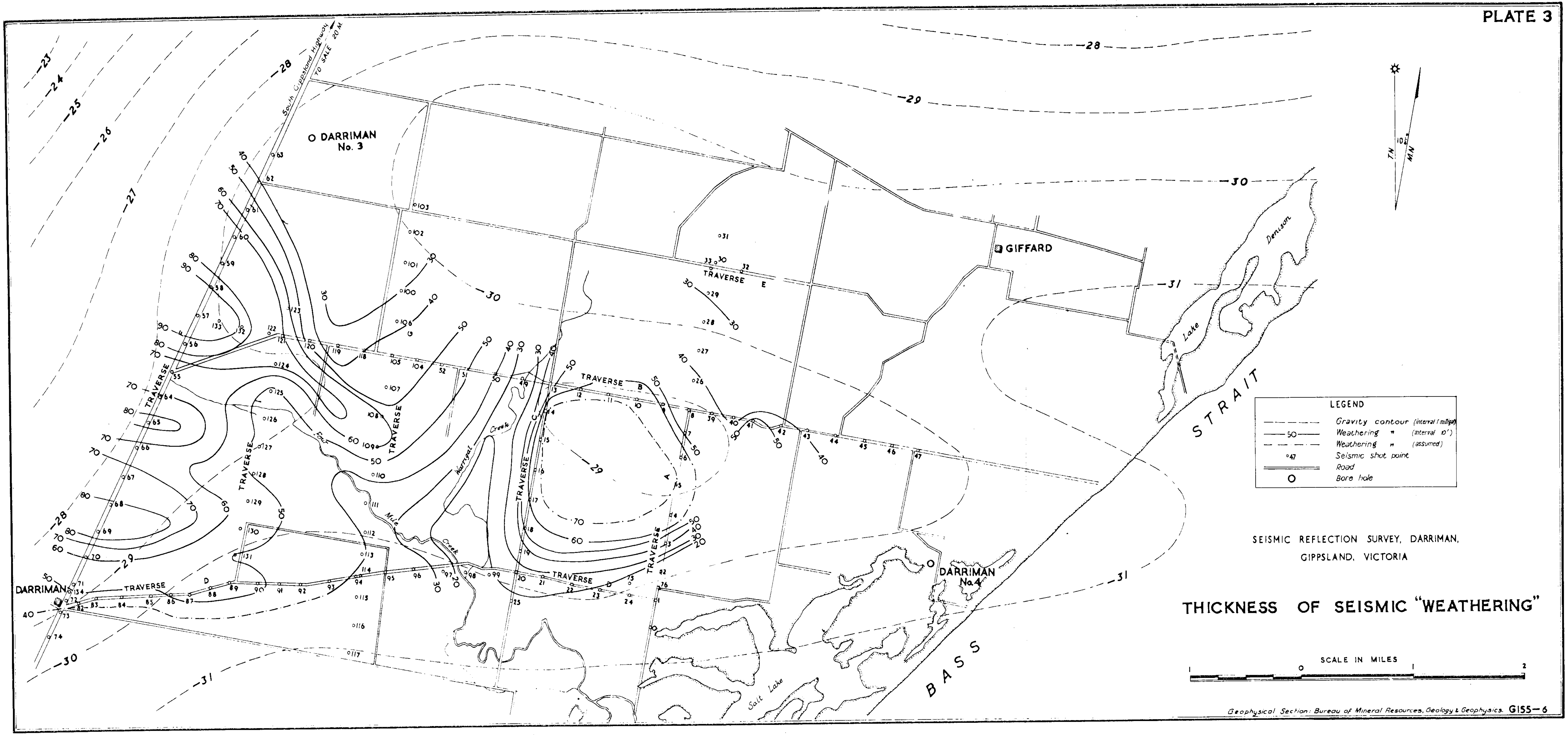

PLATE 3
DARRIMAN No. 3
GIFFARD
DARRIMAN
DARRIMAN No.4
South Gippsland Highway
TO SALE 20 M.
TRAVERSE
Lake Denison
Salt Lake
BASS
STRAIT
LEGEND
Gravity contour (interval 1 milligal)
Weathering " (interval 10')
Weathering " (assumed)
Seismic shot point
Road
Bore hole
SEISMIC REFLECTION SURVEY, DARRIMAN, GIPPSLAND, VICTORIA
THICKNESS OF SEISMIC "WEATHERING"
SCALE IN MILES
TN
MN
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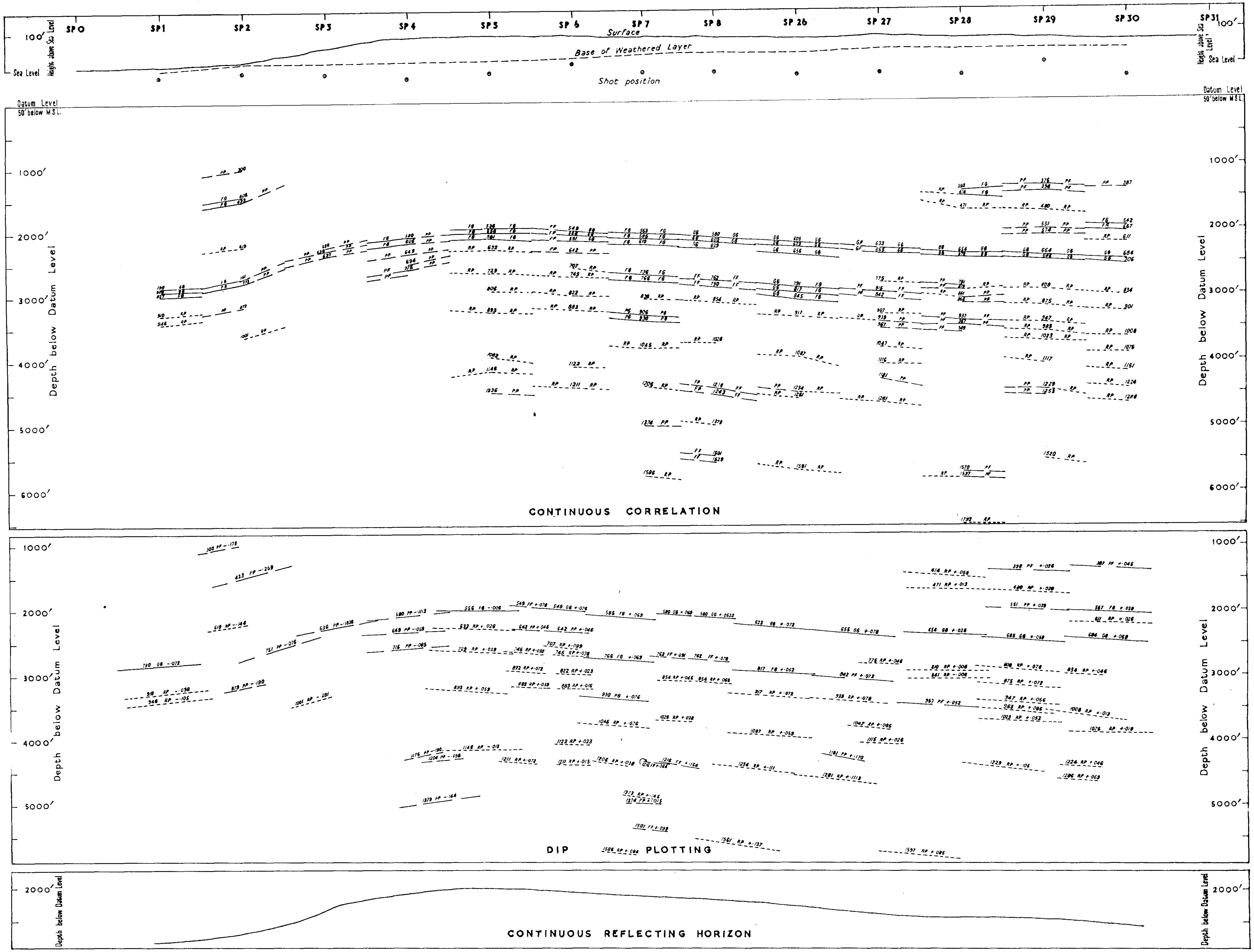
PLATE 4



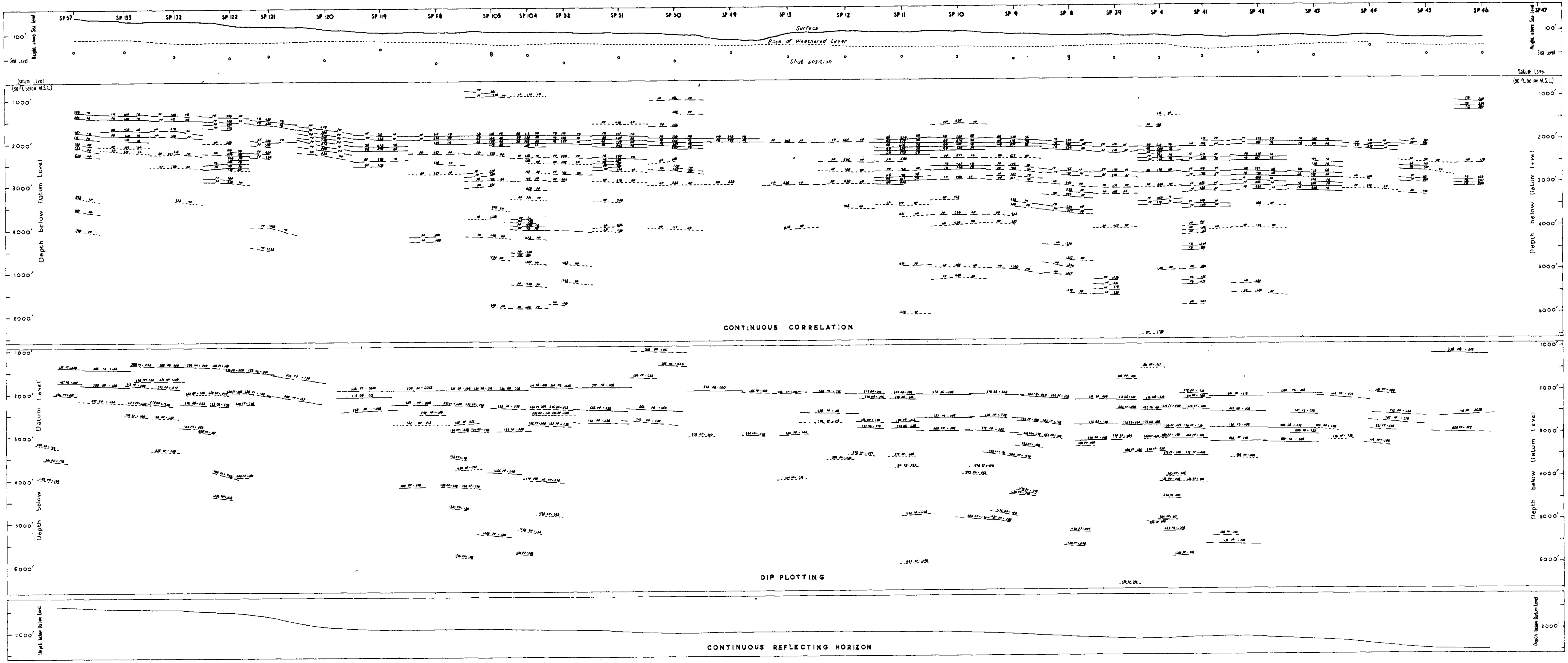
Scale in feet

1320 0 1320 2640 3960

M J Garrett
GEOPHYSICIST

SEISMIC REFLECTION SURVEY
DARRIMAN, GIPPSLAND, VICTORIA
TRAVERSE "A"

PLATE 5



Scale in feet

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M.J. Gowett
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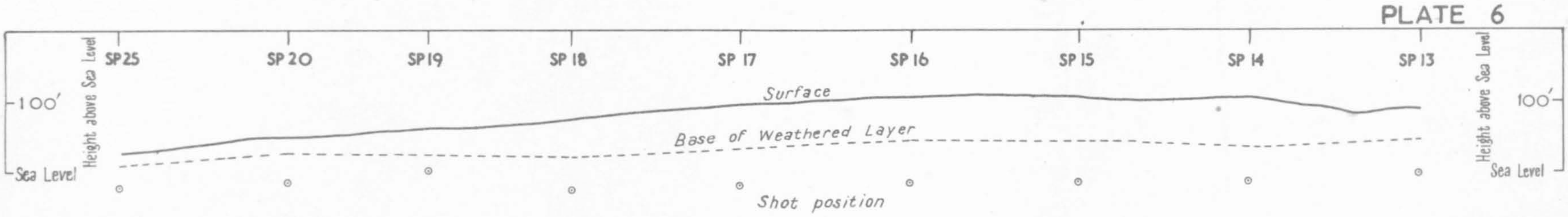
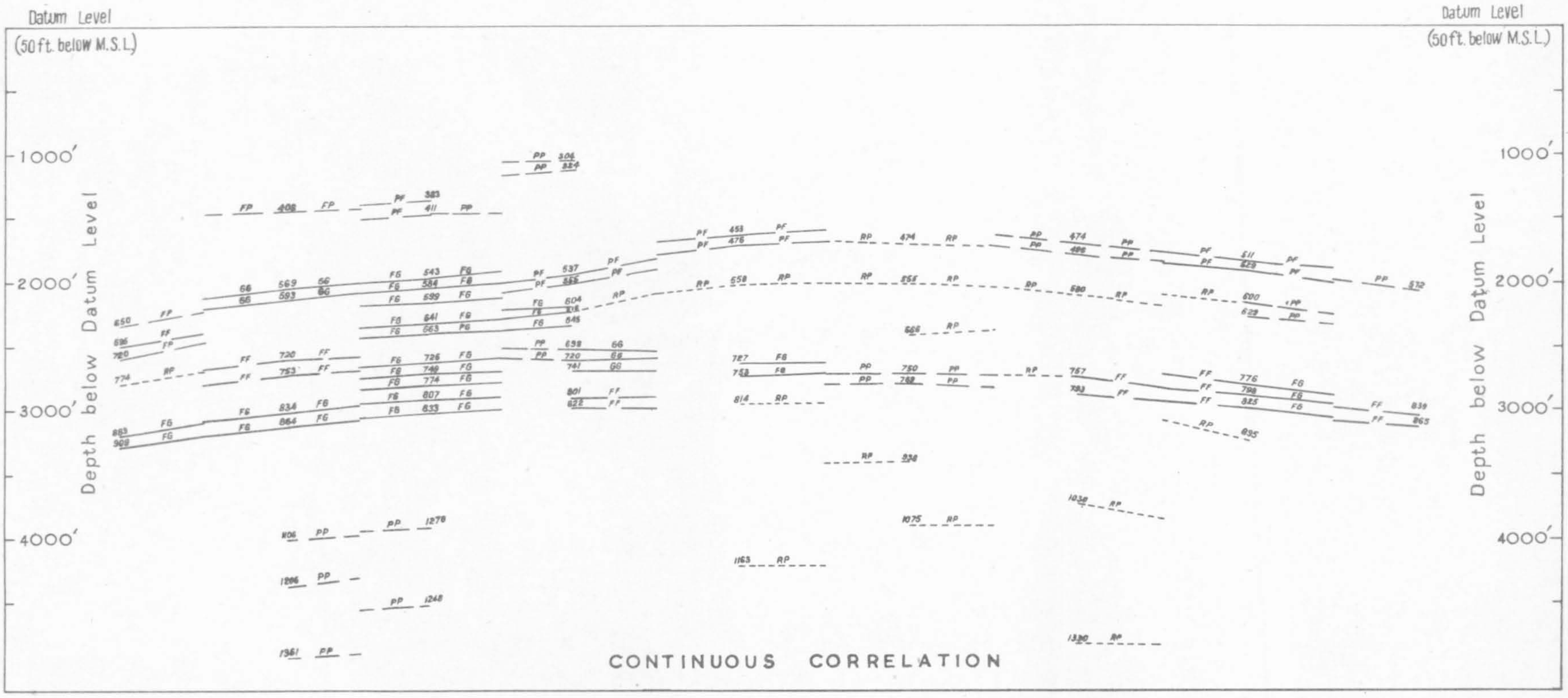
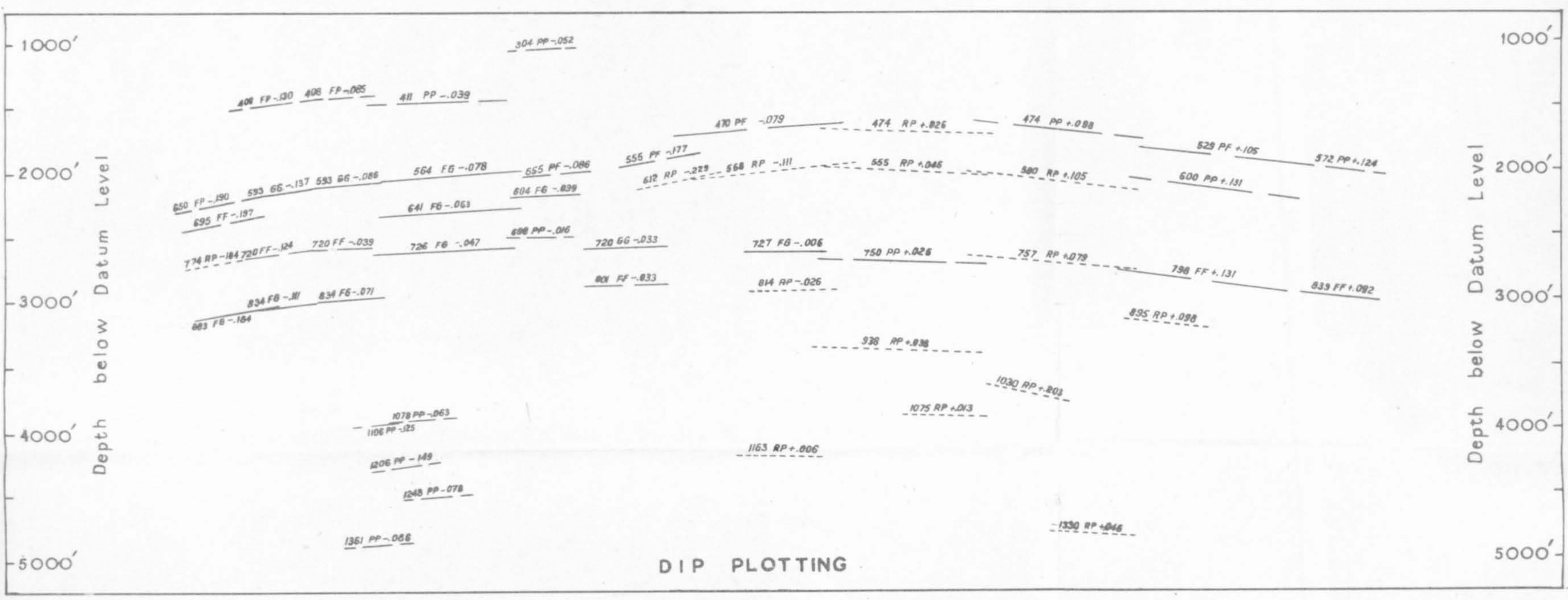
SEISMIC REFLECTION SURVEY
DARRIMAN, GIPPSLAND, VICTORIA
TRAVERSE "B"

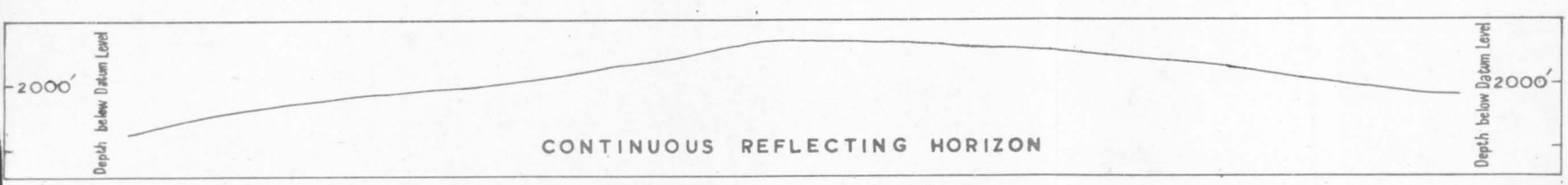
Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics G-155-8

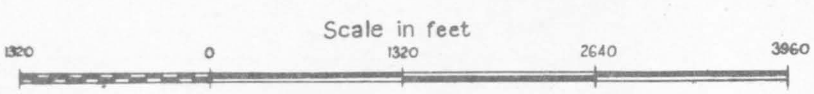
PLATE 6









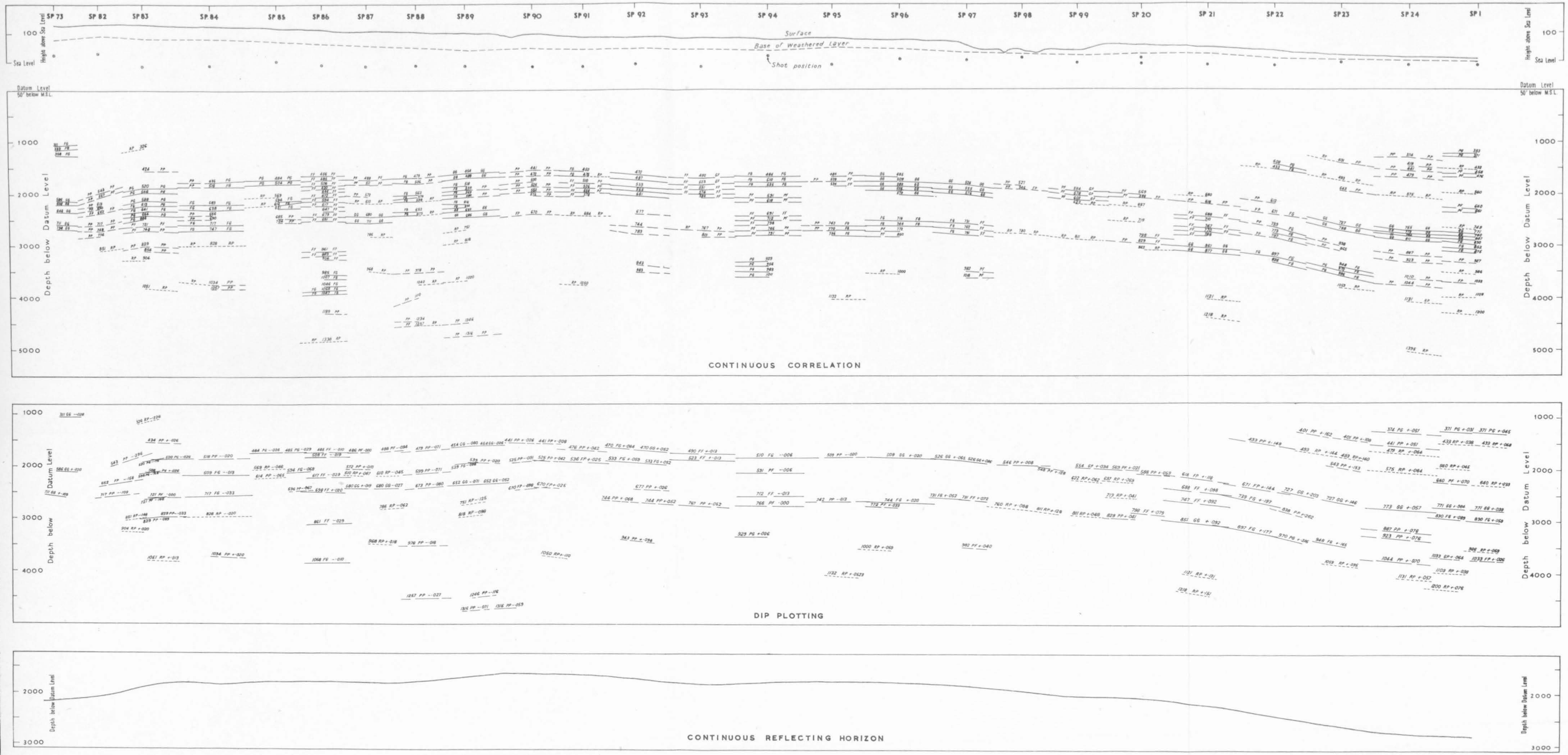


SEISMIC REFLECTION SURVEY
DARRIMAN, GIPPSLAND, VICTORIA

TRAVERSE "C"

M. J. Garrett
GEOPHYSICIST

PLATE 7



Scale in feet

1320 0 1320 2640 3960

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GEOPHYSICIST

SEISMIC REFLECTION SURVEY

DARRIMAN, GIPPSLAND, VICTORIA

TRAVERSE "D"

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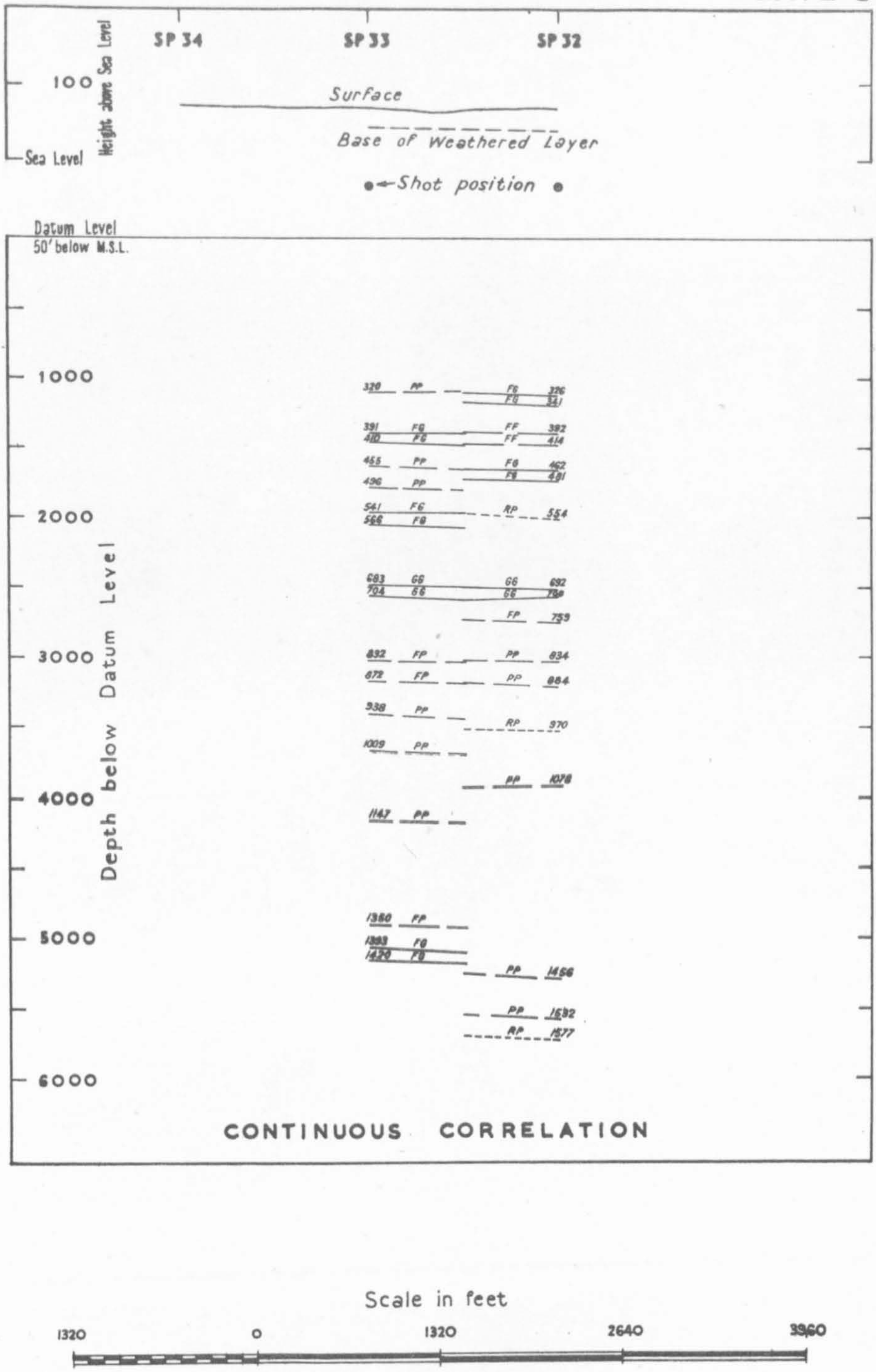


SEISMIC REFLECTION SURVEY

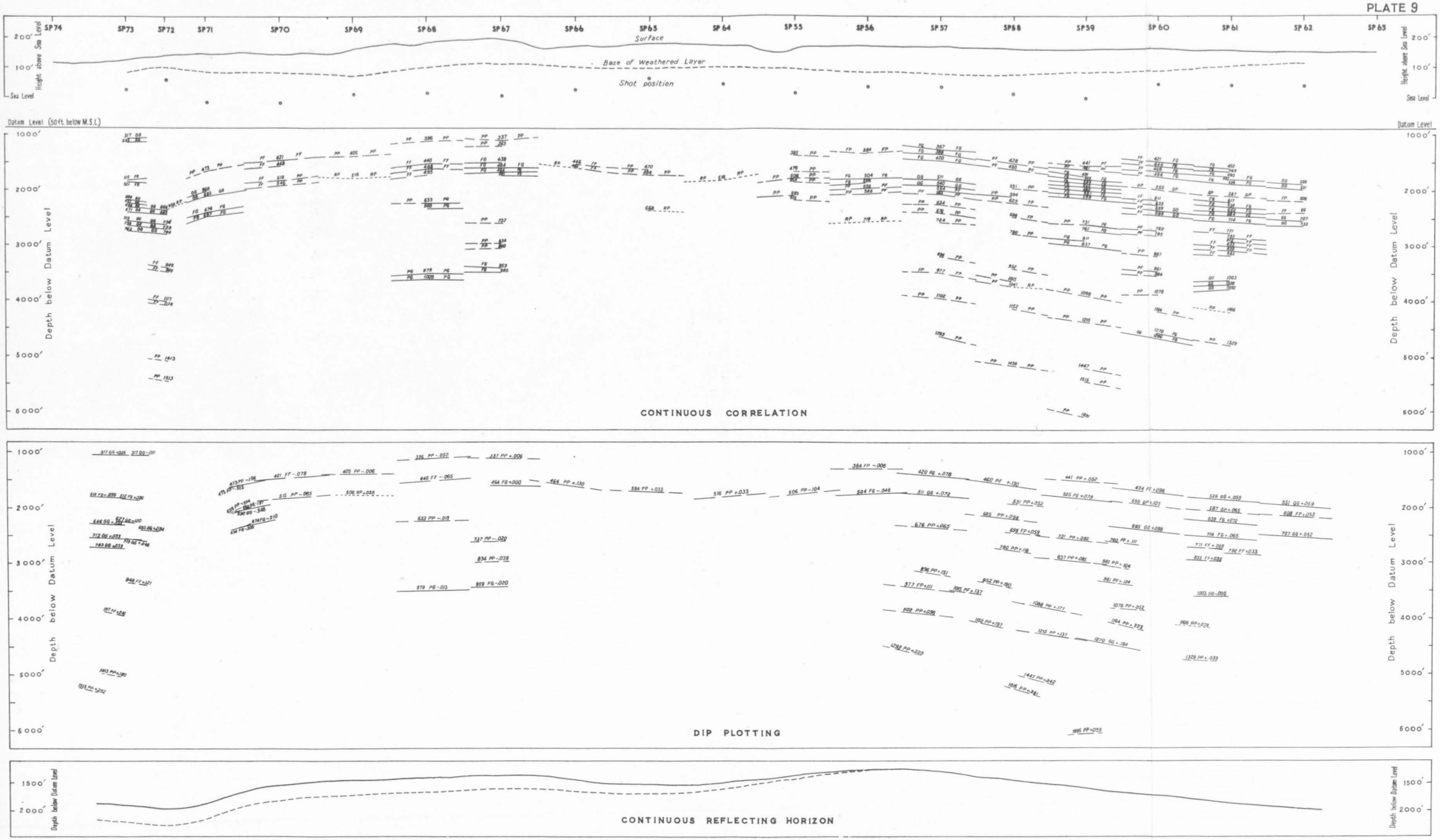
DARRIMAN, GIPPSLAND, VICTORIA

TRAVERSE "E"

M J Garrett
GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. **G155-11**

PLATE 9



Scale in feet

1320 0 1320 2640 3960

M.J. Garrett
GEOPHYSICIST

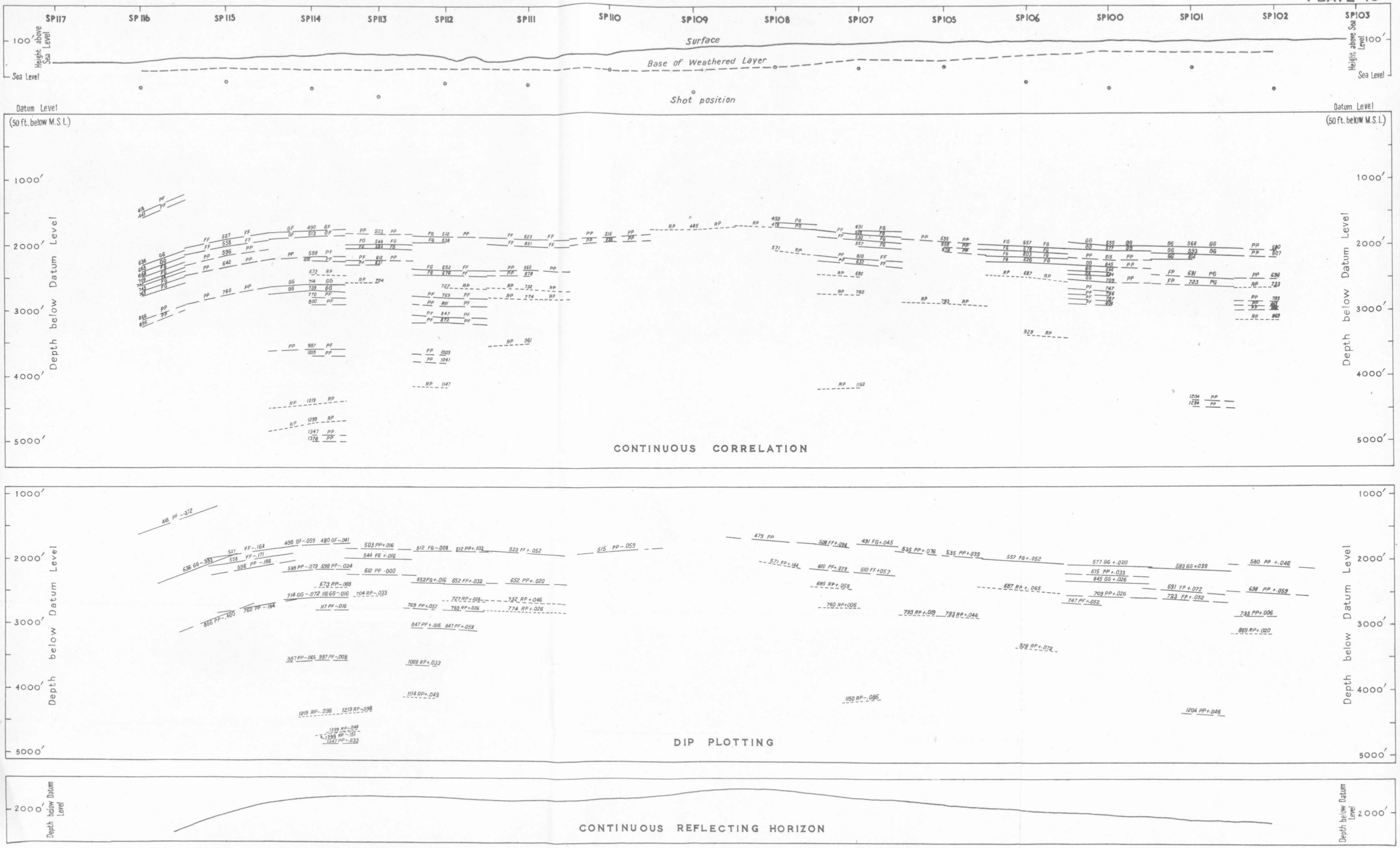
SEISMIC REFLECTION SURVEY

DARRIMAN, GIPPSLAND, VICTORIA

TRAVERSE "F"

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. G 155-12

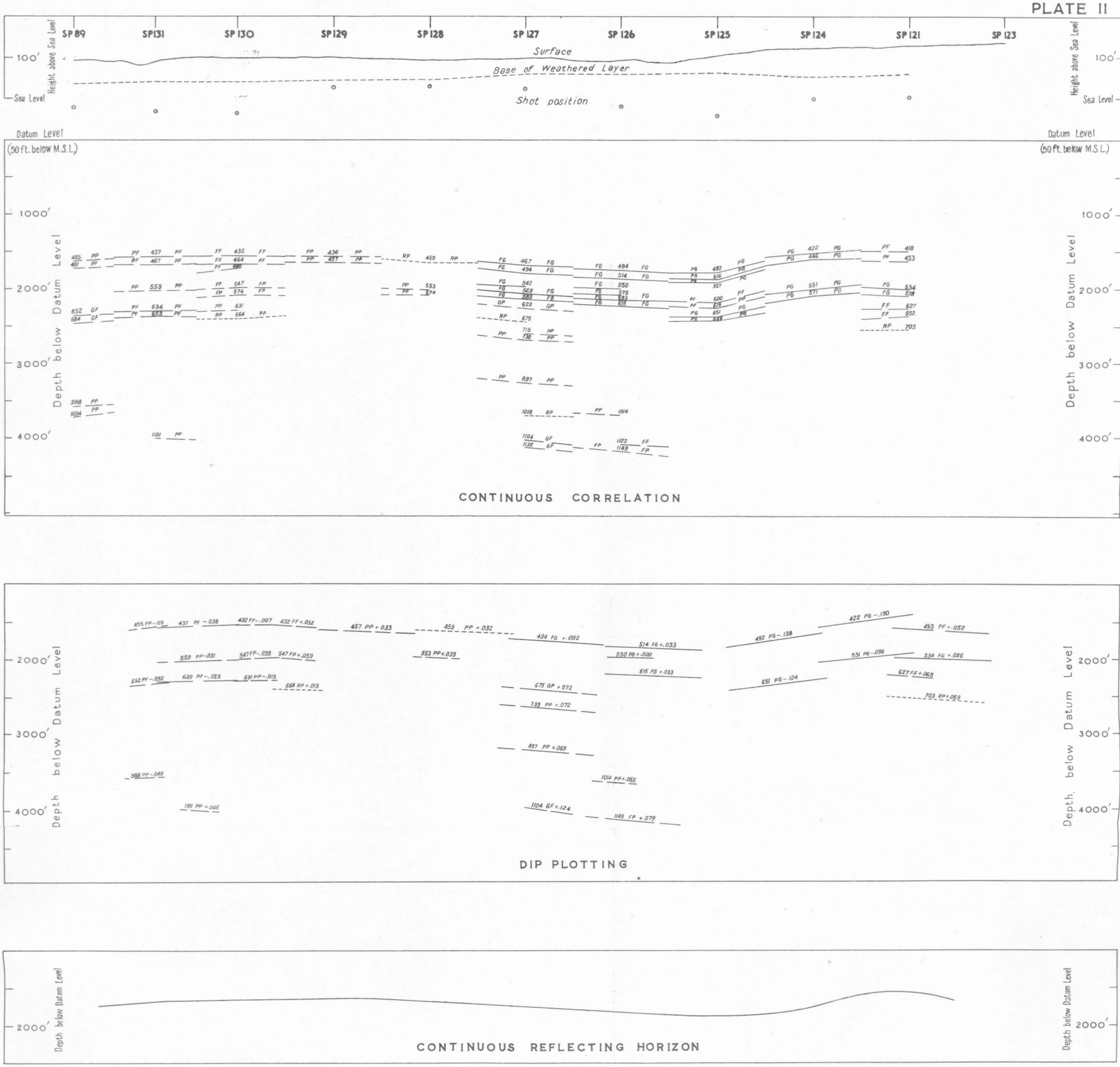
PLATE 10



M J Garrett
GEOPHYSICIST

Scale in feet
1320 0 1320 2640 3960

SEISMIC REFLECTION SURVEY
DARRIMAN, GIPPSLAND, VICTORIA
TRAVERSE "G"



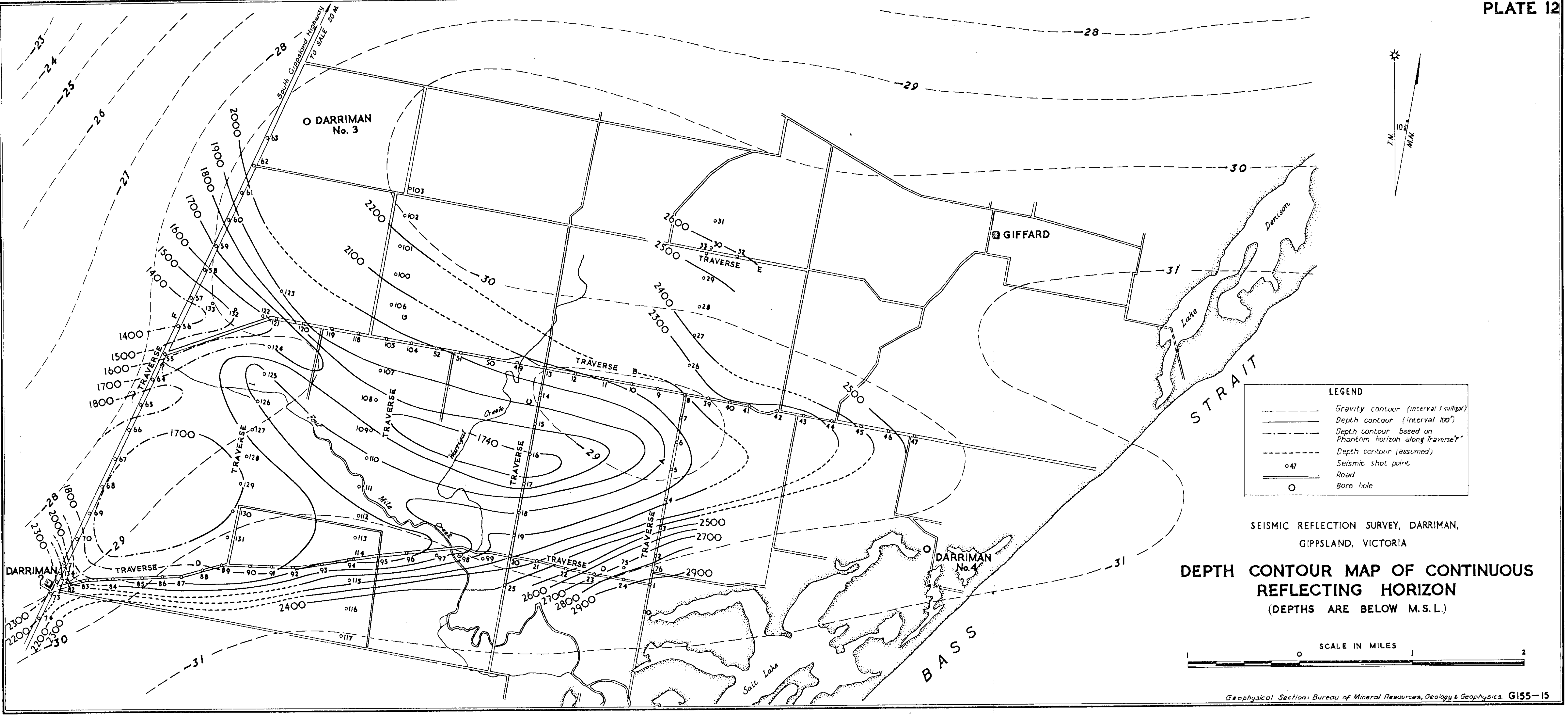
Scale in feet

1320 0 1320 2640 3960

M J Garrett
GEOPHYSICIST

SEISMIC REFLECTION SURVEY
DARRIMAN, GIPPSLAND, VICTORIA
TRAVERSE "I"

PLATE 12



SEISMIC REFLECTION SURVEY, DARRIMAN, GIPPSLAND, VICTORIA

DEPTH CONTOUR MAP OF CONTINUOUS REFLECTING HORIZON

(DEPTHS ARE BELOW M.S.L.)

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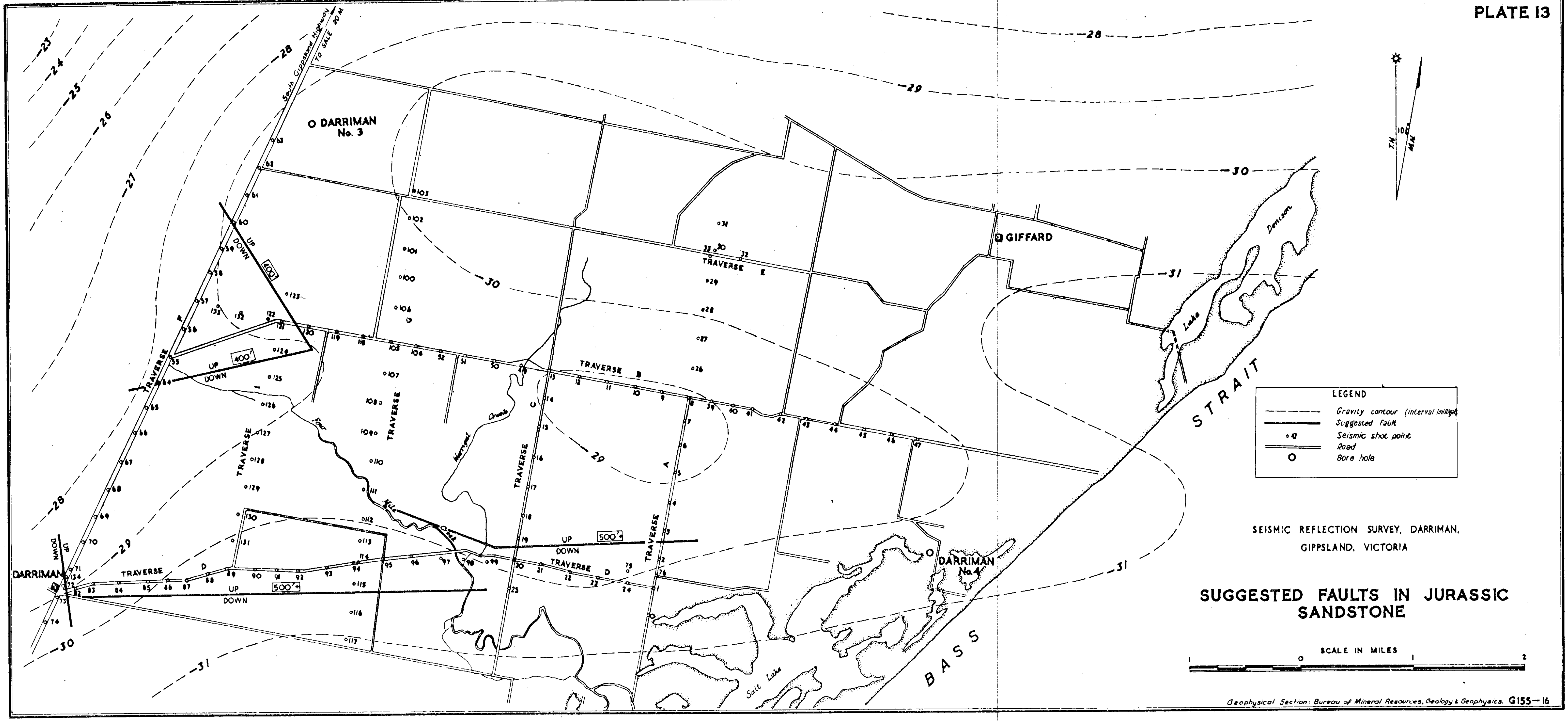

SEISMIC REFLECTION SURVEY, DARRIMAN, GIPPSLAND, VICTORIA

SUGGESTED FAULTS IN JURASSIC SANDSTONE

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