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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1965/2

EMERALD-DUARINGA SEISMIC SURVEY, QUEENSLAND 1960

by

C.S. ROBERTSON

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SUMMARY

In the second half of 1960, the Bureau of Mineral Resources, Geology and Geophysics did a seismic survey, lasting four months, in the central portion of the Bowen Basin. A single, discontinuous seismic traverse was surveyed across the Basin in an east-west direction. The results provided information on the structure and minimum thickness of sediments in the area. The reflection results are presented in the form of corrected, variable-intensity record cross-sections.

1. INTRODUCTION

From 30th July to 23rd November 1960, the Bureau of Mineral Resources, Geology and Geophysics (BMR) did a reconnaissance seismic survey in the central portion of the Bowen Basin. The objectives of the survey were to determine the structure of the Basin and the thickness of sediments by traversing from the western margin of the Basin near Anakie to the eastern margin east of Duaringa (Plates 1 and 2). This location for an east-west traverse across the Basin was chosen because of its central position in the Basin and because of the excellent access provided by the highway from Rockhampton to Emerald.

In this area the Bowen Basin is about 130 miles wide. It was decided that the best way of attaining the objectives of the survey in the four-month period available was to survey a series of reflection traverses at intervals across the Basin and to do refraction work at several selected locations. The portions of the traverse on which seismic work was done are shown in Plate 2.

Prior to the survey described in this Record, seismic work in the Bowen Basin had been done by the BMR in the Comet area in 1951 (refraction work only - Smith, 1951) and in the Cooroorah-Mount Stuart area in 1959 (Morton & Moss, 1961) and by Austral Geo Prospectors Pty Ltd for Associated Freney Oil Fields N.L. (A.F.O.) in the Banana area in 1960.

Gravity work in the Comet-Rolleston area was done by Oldham (1958), and regional gravity work that included the whole of the Emerald-Duaringa seismic traverse was done by Starkey (1959), the results of which are shown in Plate 4. A positive Bouguer anomaly (+ 5 milligals) was located near Comet, while negative anomalies were obtained west and east of Comet in the Emerald region (- 18 milligals) and Blackwater-Bluff region (- 16 milligals).

A preliminary record dealing with the principal results of this seismic survey (Robertson, 1961) has already been issued. This Record is intended to supersede the former, which was written before the variable-intensity cross-sections and final refraction interpretations were available.

2. GEOLOGY

The Bowen Basin is a large depositional area that received sediments from the beginning of the Permian period until Triassic times. The basal sediments in the Basin unconformably overlie Carboniferous and older volcanics, and other metamorphic and igneous rocks.

In the north of the Basin, the earliest Permian rocks form a thick sequence of volcanics, mainly flows, interbedded with conglomerate, sandstone, and siltstone; they are overlain locally by the Collinsville Coal Measures, and elsewhere by a thick marine sequence, which overlaps the coal measures. The marine sequence is overlain by thick freshwater sediments containing coal measures in places, of mainly Upper Permian age, which overlap the Anakie Metamorphics of the Anakie Structural High at Blair Athol. Triassic sedimentation includes conglomerate, sandstone, and siltstone.

To the south, the Basin plunges under the younger Mesozoic strata of the Great Artesian Basin, and at the western junction of the two basins a shelf area (Springsure Shelf) of sedimentation extends around the southern plunging end of the Anakie Structural High into the southern Drummond Basin.

Derrington and Morgan (1959a) recognise a number of structural zones in the area traversed during the 1960 seismic survey. Near the eastern margin of the Basin is the Dawson Tectonic Zone, which is believed to be about 40 miles wide and which is marked by steep isoclinal folds, minor basic intrusions, quartz veining and mineralisation, and low-grade metamorphism. Near the centre of the Basin is the Comet Ridge, a structural 'high' varying in width from 20 to 50 miles. Characteristic of this 'high' are broad anticlines with gently dipping flanks and sigmoidal axes, and sediments indicative of shallow-water sedimentation. East of the Comet Ridge is an Intermediate Zone about 10 miles wide and parallel to the western margin of the Dawson Tectonic Zone. The types of sedimentation and folding in this zone are intermediate between those of the Comet Ridge and the Dawson Tectonic Zone. West of the Comet Ridge is a structural depression that Derrington and Morgan called the 'Carnarvon Trough', containing a considerable thickness of Permian sediments.

The only deep bore near the seismic traverse is A.F.O. No.1 Bore (Cooroorah) drilled in 1959 about 30 miles north of the traverse. A stratigraphic log from this bore is shown in Plate 3. Stratigraphic cross-sections compiled for several other parts of the area are also shown in Plate 3. In the Springsure region, Carboniferous and Permian sediments are found in both continental and marine-paralic facies. Sediments of the continental facies, or 'Western Facies', may be expected to occur near the western end of the 1960 seismic traverse, adjoining the western margin of the Basin formed by the Anakie Structural High. On the other hand, sediments a short distance to the east of the Emerald-Yamala area are likely to resemble those of the marine facies, or 'Eastern Facies', known from the Springsure area to the south. The stratigraphic column for the Emerald-Yamala area shown in Plate 3 is a generalised one compiled from information from six bores south of Springsure (Webb, 1956). Also shown in Plate 3 is a stratigraphic column showing the relationship of rocks known from outcrop in the Comet-Mount Stuart-Bluff area (Derrington & Morgan, 1959b).

It will be noted that sediments expected to occur in the 1960 traverse area are principally Permian, overlain in some localities by Triassic sediments and lesser thicknesses of Tertiary sediments, laterite, and volcanics. For most of the region, the presence of pre-Permian sediments is doubtful.

3. FIELD WORK

The BMR Seismic Party No.1 set up camp near Comet township on 30th July 1960 and did reflection and refraction work on the western portion of the traverse across the Basin from this camp until 24th October 1960. The party then moved camp to a site near Dingo, and reflection work was done on the eastern portion of the traverse until 23rd November 1960, when the party left the area.

Despite frequent storms in the latter part of the survey, no working time was lost through wet weather. Altogether, 60 miles of reflection profiling was completed on a series of traverses spaced at intervals across the Basin.

The survey was conducted by geophysicists C.S. Robertson (party leader) and J.S. Davies, assisted by nine staff members of the BMR and ten wages employees. Two surveyors were provided by the Department of the Interior. The staff members and the main items of equipment used are listed in Appendix A.

For reflection shooting, the normal split-spread method of continuous profiling was used. For refraction shooting, the 'depth probing' method described by Vale and Smith (1961) was employed. The spread dimensions, recording parameters, and many statistics relating to the survey are set out in Appendix B. Appendix C gives shot-hole drilling statistics.

4. RESULTS

Presentation of results

The results of the reflection and refraction work done during the 1960 seismic survey are summarised in a diagrammatic cross-section along the traverse (Plate 3). On this cross-section, reflections that can be correlated from record to record have been plotted as continuous lines (not migrated to their correct positions), but the short dashes represent only the general trend of reflection dips where reflections are not continuous. Recorded refractors are also shown, and are labelled with their respective velocities. It should be noted that for convenience in presentation, the vertical scale has been exaggerated to 5.28 times the horizontal scale.

In the absence of any borehole velocity information, it has been necessary to base the depth scale on $t : \Delta t$ analyses. As the reflection quality in general was not good, this velocity data can only be regarded as very approximate. Nevertheless, the $t : \Delta t$ analyses do indicate that there is a significant difference in the average vertical velocities on either side of the Comet Ridge. Down to depths of about 5000 ft the average vertical velocities calculated from these analyses are given approximately by the following linear functions:

$$v_a = 9000 + 4300t \text{ (east of Comet)},$$

$$\text{and } v_a = 8500 + 1800t \text{ (west of Comet)},$$

where t is the two-way reflection time.

Below 5000 ft the interval velocity is assumed to increase progressively less rapidly until it reaches a constant value of 21,000 ft/s at a depth of 30,000 ft west of Comet, and at a depth of 25,000 ft east of Comet. It should be noted that, apart from a single deep refractor recorded on Traverse A near Blackwater, no velocity information is available from below about 5000 ft. The depths of the deeper reflections plotted in Plate 3 may therefore be in error by as much as 20 percent. The velocity distribution for the Comet Ridge is probably different from those for the sedimentary troughs on either side. In the absence of more reliable information, the velocity distribution for the eastern trough was used for Traverse B on the Comet Ridge, as velocities on the Ridge may be expected to be relatively high.

A $t:\Delta t$ analysis of reflections on Traverse M near Duaringa indicated much lower average vertical velocities for sediments there; it is assumed that the average vertical velocity down to 4000 ft is given by:

$$v_a = 5000 + 1500t \text{ (Duaringa area)},$$

where t is the two-way reflection time. Below 4000 ft an arbitrary interval-velocity curve was adopted, such that a constant vertical velocity of 21,000 ft/s was reached at 24,000 ft.

Below the diagrammatic seismic cross-section in Plate 3, a regional Bouguer gravity anomaly curve (Starkey, 1959) has been drawn at the same horizontal scale. Below this is geological information that has already been discussed and an interpretative cross-section illustrating all the information at an approximately natural scale.

The reflection results have also been presented in the form of corrected variable-intensity record cross-sections made by means of a Texas Instruments Incorporated Variable Intensity Plotter (Plates 13 to 30). In the cases of several traverses where steeply dipping events were recorded, 'migrated' cross-sections are also presented, in which the most prominent events have been plotted approximately in their true positions assuming that the ray paths are segments of circles. The corrected refraction results are shown plotted in Plates 5 to 11, which also show on cross-sections the likely ray paths to the various refractors that were recorded.

Discussion of results

It is convenient to consider the seismic results by starting at the western end of the series of traverses and proceeding towards the eastern end.

West of Emerald. Traverses E and H (Plate 2) were surveyed, partly to locate the western margin of the Bowen Basin in this area and partly to see if there were any indications of unmetamorphosed pre-Permian sediments resting on the metamorphics of the Anakie Structural High. On Traverse H, immediately east of Taroborah, refraction work indicated the presence of refractors with velocities of 12,350 ft/s and 18,300 ft/s at depths of about 500 and 2400 ft respectively (Plate 9), while near the western end of Traverse E a refractor with a velocity of 19,400 ft/s was recorded about 500 ft from the surface (Plate 8). No shallow reflections were recorded on either of these traverses, but many deeper reflections were recorded on both of them (Plates 20 & 23). These mainly indicated steep but erratic dips and the reflections can rarely be correlated over more than two records. On Traverse E, reflections were sometimes of fair quality but dips were erratic. On Traverse H, dips were erratic down to 3.0 seconds, but were sub-horizontal below this. Reflections continued to arrive for as long as 6 seconds. This is in marked contrast with results at most localities within the Basin, where reflected energy was rarely received after 2.5 seconds, even when heavy charges were used.

It is concluded that Traverse E is close to the margin of the Bowen Basin and that it is underlain mainly by strongly folded metamorphic and predominantly crystalline rocks, in which seismic energy is not attenuated as rapidly as in most of the sediments of the Bowen Basin. There is a low-velocity (6500 ft/s) layer about 50 ft thick at the surface on Traverse E. This may represent a thin layer of Permian or even Tertiray sediments, or it may be a deeply weathered layer of metamorphic rocks. The 19,400-ft/s refractor evidently represents the top of the metamorphic rocks, i.e. the Anakie Metamorphics. This refractor has a very irregular surface and may be faulted.

On Traverse H, it is probable that the 12,350-ft/s refractor represents Permian rocks and that the 18,300-ft/s refractor represents metamorphic rocks. Thus there is an increase of 2000 ft in the thickness of unmetamorphosed Permian sediments between Traverses E and H. The difference of 1100 ft/s in the velocities measured in the metamorphics may not be significant, particularly as the measurement on Traverse H is not very accurate owing to lack of subsurface overlap. Any actual difference in velocity may be explained by a variation in metamorphic rock type, rather than by the existence of more sediments above the metamorphics. In any case, it is certain that there is a fairly rapid increase in thickness of non-metamorphic rocks between Traverses E and H. It may be concluded, therefore, that the western margin of the basin lies close to Traverse E. Although the non-metamorphic rocks increase in thickness between Traverses E and H, the refractors recorded on these traverses show no evidence of easterly dip. This might be an indication that the western margin of the Basin is determined by faulting rather than by down -warping.

Traverse D was surveyed for seven miles westwards from near Emerald. Basalt occurred near the surface along most of this traverse and reflection quality was generally very poor (Plate 19). Only a few reflections were recorded on the western half of the traverse. These were poor in quality but generally suggested an easterly component of dip along the traverse. Reflection quality was a little better near the centre of the traverse although still poor. Reflections on this portion of the traverse consistently indicated a moderate amount of east dip. More reliable reflections were recorded near the eastern end of the traverse, particularly from shallow depths. These indicated strata with more gentle dips to the east. Near the eastern end of the traverse some reflections were recorded up to at least two seconds, which is estimated to correspond to a depth of roughly 12,000 ft. However, there is no definite limit on the records, after which no reflections were recorded, so it is difficult to estimate the minimum thickness of sediments that may be present. Reflection quality generally deteriorated with depth. There is no indication of the presence of an unconformity although reflection quality, even near the eastern end of the traverse, is scarcely good enough to give a clear indication of whether the strata are conformable down to 12,000 ft or not. It does seem likely that the strata are more or less conformable down to about 7000 ft at the eastern end of Traverse D.

Sediments of the Colinlea Formation, of Lower Permian age, outcrop on the western end of Traverse D and, according to the report by Shell (Queensland) Development Pty Ltd (1952), extend in outcrop as far west as Taroborah. This formation is thought to have a maximum thickness of 4500 ft. It is possible that the 18,300-ft/s refractor recorded on Traverse H may represent the base of the Colinlea Formation. Reflection quality on Traverse D was much too poor to give any indication of whether pre-Permian sediments are present or not.

Two refraction shots were recorded with the geophones near the centre of Traverse D, using shot-geophone distances of $5\frac{1}{2}$ to $6\frac{1}{2}$ miles to the west and 7 to 8 miles to the east. The plotted results are shown in Plate 7. Apparent velocities of 13,400 ft/s and 18,030 ft/s were recorded shooting from the west and east respectively. However, considering the large distance between shot-points, it is not certain that the events recorded were from the same refractor. Interpretation is impossible without further field work. This refraction work was done at the end of the survey and no time was available for additional shots.

Emerald-Yamala area. Between Emerald and Yamala, nine miles of reflection traverse were surveyed in two sections with a small gap between them (Plate 2). The reflection results are shown in Plate 17. Results were poor to fair on the eastern section of the traverse but generally very poor on the western section, where there was a layer of about 25 ft of gravel near the surface, which prevented drilling below this depth.

On the eastern portion of the traverse, reflections indicated a westerly component of dip. The dip increases from about 2 degrees for reflectors about 1700 ft deep (0.4 seconds) to about 15 degrees for reflectors about 10,000 ft deep (1.7 seconds). The variable-intensity cross-section shows no obvious sign of an unconformity, although reflection quality is not good enough to establish with certainty that no unconformity exists. There is no definite limit to the depth from which reflections were recorded and it is very difficult to estimate what total thickness of sediments might be present on this traverse. Strong reflections, indicating moderate dips, were recorded beyond 1.8 seconds reflection time, which probably corresponds to about 10,000 ft in depth. It is therefore probable that at least 10,000 ft of sediments are present.

On the western portion of Traverse C, reflections generally indicate slight dips towards the east. Between Shot-points 227 and 106 the deeper reflections, which are of poor quality, indicate westerly dips of about 11 degrees. There is some suggestion that there may be an unconformity between 7000 and 10,000 ft, but this is by no means certain because of the poor reflection quality. Steeply dipping events recorded west of Shot-points 106 and 223 may be diffractions from faults near these shot-points.

A short cross-traverse, surveyed at right angles to Traverse C, 2 miles west of Yamala, indicated little or no dip component in the cross-traverse direction (Plate 18).

Two refraction 'depth probes' were made on Traverse C, towards the eastern and western ends. The velocities recorded from the two 'depth probes' were different although the shot-to-geophone distances were comparable. The plotted results are shown in Plate 6. The interpretation of these refraction probes was made assuming the forward and reverse shots recorded the same refractor. On the eastern portion of the traverse a refractor with a velocity of 17,100 ft/s was recorded from a depth of about 3900 ft, while on the western portion of the traverse a refractor with a velocity of 15,750 ft/s was recorded from a depth of about 2660 ft. These velocities are considered to be too low to represent the metamorphic rocks of the Anakie area, which are therefore greater than 4000 ft deep, but, compared with velocity measurements elsewhere in the Basin, they could be from refractors within the Permian section.

The results on Traverse C indicate that a trough of sediments exists with a possible thickness of at least 10,000 ft and that the sedimentary rocks are thickest near the centre of the traverse. The sediments in the Emerald-Yamala area are believed to be Permian, probably corresponding to the 'Eastern Facies' sediments of the Springsure region.

Comet Ridge. The BMR made a refraction survey on the Comet Ridge in 1951 (Smith, 1951), the main results of which are shown in Plate 3. An 18,150-ft/s refractor was recorded from a depth of only about 2200 ft. A similar refractor was recorded by the BMR in 1959 (Morton & Moss, 1961) from about the same depth near Mount Stuart, about 30 miles to the north. It is most probable that these refractors represent the same horizon. Drilling of A.F.O. No.1 Bore (Cooroorah) indicated that this horizon is the top of a very hard sandstone. As in the trough west of the Comet Ridge, refraction work east of the Comet Ridge indicated that refractors with velocities of about 18,000 ft/s are at a much greater depth than 2200 ft. Hence this refraction work confirms the existence of an uplift in the Comet area.

During the 1960 seismic survey, reflection work was done on the central part of the 1951 traverse (Traverse B). As single-hole shooting proved ineffective, about three miles of traverse was surveyed using nine-hole pattern shots. At times less than 2 seconds (about 16,000 ft) only a few poor reflections were recorded, which indicated dips varying greatly in direction and amount of dip (Plate 16). Reflections later than 2 seconds were common; they mostly indicated steep and erratic dips, but reflections recorded at about 2.2 to 2.4 seconds indicated consistent westerly dips and could in many cases be correlated from record to record.

The relatively shallow depth of the 18,150-ft/s refractor on the Comet Ridge, together with the fact that reflection and refraction work on either side indicated dips away from the Ridge, confirms geological and gravity evidence that sediments are thinner on the Comet Ridge. However, the actual thickness of sediments in this area is still open to question. In the troughs on either side of the Ridge, conformable reflections were recorded from depths greater than the depth of refractors having velocities of about 18,000 ft/s. If these refractors in the troughs can be correlated with the 18,150-ft/s refractor on the Comet Ridge, then sediments may extend well below 2200 ft in this area.

The persistent reflections at about 2.3 seconds on Traverse B indicate that there is a marked discontinuity with a westerly dip component at about 17,000 ft, but what this represents is uncertain. The variable dips indicated by deeper reflections probably result from the fact that the rocks below the 17,000 ft discontinuity are strongly folded.

Traverses F and G were surveyed on the eastern and western flanks of the Comet Ridge respectively. Reflection Traverse G was surveyed for three miles, centred about three miles west of Comet township. It can be seen from Plate 22 that the results obtained were too poor to provide any reliable information. Reflection Traverse F was also about three miles long, surveyed eastwards from Tolmies. The results of this traverse are shown in Plate 21. Reflection quality was generally poor but a number of reliable reflections were recorded. These tend to suggest easterly component of dip. At least one steeply dipping event was recorded near Shot-point 307 in the centre of the traverse. This may represent a diffraction from a fault.

Blackwater-Bluff area. Traverse A was a continuous reflection traverse eleven miles long between Blackwater and Bluff. A complete refraction 'depth probe' was made near its western end to record all possible refractors. The reflections obtained on this traverse were the best for the whole survey and could frequently be correlated continuously from record to record for some miles. The principal reflection recorded on the eastern portion of the traverse was exceptionally strong.

Plate 13 shows the reflection results from Traverse A in corrected, variable-intensity form. Plate 12 is an overlay for Plate 13 summarising the main reflection results. In Plate 14 the reflection events illustrated in Plate 12 are shown after having been 'migrated' or plotted in their correct horizontal and vertical positions, assuming that the seismic velocity increases in a linear manner with depth and that ray paths from shot to reflector and back are consequently arcs of circles. The velocity functions assumed for this plotting were:

$$v_i = 10{,}000 + 1.0\ d \text{ (for reflections shallower than 12,000 ft)}$$

$$v_i = 10{,}000 + 0.87\ d \text{ (for reflections deeper than 12,000 ft)}$$

where v_i is the interval velocity and d is the depth.

It is seen from Plate 13 that, with the exception of a small portion of the traverse near the eastern end, reflections generally indicate easterly dip component. The amount of dip component eastwards along the traverse varies from about 4 degrees near the western end of the traverse to about 28 degrees from some of the deeper reflections near Shot-point 82. A short cross-traverse, roughly at right angles to Traverse A and about a mile in length, was surveyed through Shot-point 23. The results of this short traverse showed (Plate 15) that the strata in this area also exhibit a considerable southerly dip component. The true dip is thus roughly in the south-east direction. The angles of dip perpendicular to the strike of the beds will of course be somewhat greater than the apparent dips shown in Plate 13.

Seismic energy was generally recorded until 1.5 to 2 seconds after the shot, and reflections were often recorded for as long as the energy persisted. Consequently it is again impossible to place an upper limit on the thickness of sediments present. However, it is likely from reflection results that the thickness of sediments is at least 12,000 ft near the eastern end of thetraverse, and may be much greater in the area south-east of Traverse A. It is known from the near-surface geology in the vicinity of Bluff that the top part of this section is Triassic and Permian.

Five refractors were recorded near the western end of the traverse, including a 17,500-ft/s refractor at about 3900 ft and a 19,700-ft/s refractor at 7700 ft. The latter velocity is extremely high and suggests that rocks below this refractor are metamorphic or igneous. However, all refraction velocities in this area are unusually high, and the 19,700-ft/s refractor might represent the top of pre-Permian sediments, since a number of reflections appear to have been recorded from below this level.

Near the eastern end of Traverse A, a large number of events were recorded that apparently indicated westerly component of dip. Some of these westerly-dipping events overlap easterly-dipping events in Plate 13. The interpretation of structure in this area is very difficult from the results of only one traverse, which was by no means at right angles to the direction of strike. However, it is clear that the very strong easterly-dipping reflection recorded at about 0.6 seconds near the eastern end of the traverse is absent in the vicinity of Shot-points 94 and 95. It is likely that this reflection, and others, is affected by a fault or faults. However, nothing definite about the strike of the fault can be learned from this single traverse and it is doubtful that the fault plane (or its intersection with the vertical plane through the traverse) can be recognised on the variable-intensity cross-section.

It is possible that some of the westerly-dipping events are diffractions from irregularities such as faults. It is considered more likely, however, that these represent 'reflected refractions'. They were probably produced when seismic energy was refracted along beds dipping to the south-east, reflected from a fault or other discontinuity located south-east of the shot-points, and refracted back up to the geophones along similar paths. Without knowing more about the exact directions of strike and amounts of dip of the strata and faults that may be present, it is impossible to test this theory fully.

Numerous faults are known from surface and underground geological mapping in the Bluff area just east of Traverse A. This faulting makes it difficult to correlate the very strong reflection recorded on Traverse A across the 1½-mile gap between Traverses A and J (east of Bluff).

Reflection results on Traverse J (Plate 25) were of comparable quality with those of Traverse A. A 'migrated' cross-section (Plate 26) has been plotted for Traverse J in the same way as for Traverse A and using the same velocity functions. On the western portion of Traverse J, reflections indicate an easterly component of dip as on the greater part of Traverse A. It is apparent that the Triassic and Permian sediments on Traverse A, although somewhat disturbed by faulting in the vicinity of Bluff, continue to increase in thickness towards the east as far as Shot-point 341 on Traverse J. At this shot-point strong reflections indicating an easterly component of dip were recorded up to about 2.4 seconds reflection time. This indicates that relatively unfolded strata may attain a thickness of about 20,000 ft in this area.

Near the eastern end of Traverse J, events with fairly steep slope to the west were recorded as on the eastern end of Traverse A. It is possible that these events are also 'reflected refractions' produced by reflection of refracted seismic energy from a fault or series of faults near the eastern end of Traverse J. However, the gravity results (Plates 3 & 4) indicate that, whereas the faulting on Traverse A must be on a minor scale, producing little or no gravity change, there is a structural feature of major proportions near the end of Traverse J, possibly a major fault or fault zone. From reflection results it is likely that Traverse J is cut by a fault in the vicinity of Shot-point 349 but the strike, dip, and throw of the fault are unknown. However, it is unlikely that a normal fault of major proportions would occur on the edge of a strongly compressed and folded region such as the Dawson Tectonic Zone. It is considered likely, therefore, that any major faults occurring near the eastern end of Traverse J are reverse or overthrust faults caused by lateral compression.

Dawson Tectonic Zone. On Traverse K (near Dingo) and Traverse L (near Tryphinia), no shallow reflections were recorded but many deep reflections were (Plates 27 & 28). The latter mainly indicated steep dips in both easterly and westerly directions. The reflections could not generally be correlated continuously from record to record. They suggested the presence of strongly folded rocks such as would be expected in the Dawson Tectonic Zone. After about 3 seconds many near-horizontal reflections were recorded, especially on Traverse L. Reflections similar to these were also recorded after about 3 seconds on Traverse H. These evidently come from within a basement of igneous rocks or granitised sediments; in the Dawson Tectonic Zone this basement is apparently overlain by about 20,000 ft of folded rocks.

Duaringa area. On Traverse M, surveyed south-westerly from Duaringa, a number of continuously correlatable reflections from relatively shallow depths were recorded over a distance of 1½ miles (Plate 29). These indicated a small south-westerly dip component and a minimum thickness of about 3000 ft of undisturbed sediments. On the western half of Traverse M few reflections were recorded from single shot-holes. However, two nine-hole pattern shots were fired on this part of the traverse and they indicated that the reflecting layers may persist along the whole of the traverse although they are more difficult to record on the south-western half. Two shots a quarter of a mile apart were fired about half way between Traverses L and M but no shallow reflections were recorded. There were a few very weak events, which indicated steep dips, evidently from folded rocks at depth. It is believed that the shallow reflections on Traverse M come from Tertiary sediments.

Traverse N was surveyed for three miles east from the Dawson River. No correlatable reflections were recorded before 1.8 seconds reflection time (Plate 30). After 1.8 seconds, which may correspond to a depth of the order of 14,000 ft, a number of correlatable reflections were recorded. These indicated westerly dip component and probably represented reflections from below igneous ro metamorphic basement surface such as were recorded after 3 seconds on Traverse L.

A refractor with seismic velocity 17,050 ft/s was recorded near the centre of Traverse N from a depth of about 900 ft below the surface (Plate 11). This refractor showed a steep dip component towards the west and evidently represents the top of the undifferentiated Lower Palaeozoic rocks, which outcrop a little to the east of Traverse N.

Comparison of seismic and gravity results. A Bouguer anomaly contour map prepared from maps by Starkey (1959) is shown in Plate 4. In broad outline the regional Bouguer anomaly curve along the seismic traverse line (Plate 3) appears to agree with the structure as revealed by seismic work and geological mapping assuming that the gravity anomalies are due to basement relief. The Comet Ridge is clearly shown as a gravity 'high', supporting the view that basement is relatively shallow in this area. On either side of the Comet Ridge there are gravity 'lows' corresponding to portions of the traverse line where seismic work indicates the presence of considerable thicknesses of sediments. At each end of the traverse there are gravity 'highs' produced by older and denser basement rocks near the surface. Across the Dawson Tectonic Zone the Bouguer gravity anomaly curve is almost horizontal and slightly positive, suggesting that basement rocks are shallower than in the Blackwater-Bluff area, which lies west of it.

The postulated cross-section at the bottom of Plate 3 is based on both seismic and gravity results. Basement depth on the cross-section is derived from the estimated depth on Traverses H, K, and L of the top of the horizontal reflectors that produce reflections after 3 seconds. Calculations of depth differences, based on the Bouguer gravity anomaly curve, have been used to interpolate between Traverses H, K, and L; in these calculations it was assumed that the anomalies are due to relief along a boundary with density contrast of 0.2 g/cm^3.

Structure shown on the cross-section is consistent with the seismic results but, because of the many gaps between seismic traverses and the poor results on some traverses, it must be emphasised that the cross-section is largely hypothetical.

5. CONCLUSIONS

The 1960 seismic survey confirmed the existence of the Comet Ridge, sediment-filled troughs on each side of the Comet Ridge, and the Dawson Tectonic Zone. It also revealed the presence of a small trough or sub-basin of relatively undisturbed sediments near Duaringa. A number of possible or probable faults were located and a considerable amount of information was obtained on the dip of the sediments and on seismic velocities at various depths.

It was determined that the western margin of the Bowen Basin is a few miles west of Taroborah and the eastern margin several miles east of the Dawson River. Seismic results indicated that the sedimentary trough west of the Comet Ridge contains at least 10,000 ft of sediments and that the trough east of the Comet Ridge possibly contains as much as 20,000 ft of sediments. In both cases the sediments appear to be gently down-warped with little sign of disturbance except on the eastern side of the eastern trough, near Bluff, where there is evidence of extensive faulting. South-west of Duaringa it was shown that there are 3000 ft or more of relatively undisturbed sediments, which are probably Tertiary. The seismic results gave no indication of the presence of significant structural traps that might contain hydrocarbons, but such traps would not necessarily have been revealed by a survey of this kind.

Reflection quality varied greatly within the survey area. It was best near the deeper portions of the sedimentary troughs and very poor near the Basin margins and near the Comet Ridge, where thinner sections of Permian sediments were expected. It was in these latter areas that it was particularly hoped to obtain information on the rocks below the Permian sediments. Unfortunately reflection quality was too poor for this, with the exception of some extremely deep events. It is not known, therefore, whether there are sediments older than, and more or less conformable with, the Permian sediments. This question might be resolved by detailed, continuous refraction profiling to plot the eastward extension of the refractors recorded on Traverses E and H. Deep reflections obtained in the Dawson Tectonic Zone indicate that folded rocks there persist to a depth of about 20,000 ft; just east of Taroborah it was shown that metamorphic rocks, which are presumably folded, also persist to a depth of about 20,000 ft. Below these metamorphic rocks, there is almost certainly an igneous basement, which apparently gives rise to consistently horizontal reflections.

In the sedimentary troughs on each side of the Comet Ridge no refractor of 18,000 ft/s was recorded within several thousand feet of the surface. Therefore the very hard sandstone encountered at about 1600 ft in the Cooroorah bore either does not extend into the troughs owing to a facies change or is much deeper.

6. REFERENCES

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APPENDIX A

Staff and equipment

Staff

Party leader	C.S. Robertson
Geophysicist	J. Davies
Surveyors	W. Richards, R. Mathews or N. Wilson
Clerk	W. Rossendell
Observer	G. Abbs or L. Vliegenthart
Shooter	E. Cherry
Toolpusher	J. Halls
Drillers	B. Findlay, J. Lambert
Drilling assistants	J. Chandler, F. Blackwell
Mechanics	I. Pirie, H. Robertson

Equipment

Seismic amplifiers	Technical Instruments Co. (T.I.C.)
Seismic oscillograph	T.I.C. 50-trace
Magnetic recorder	Electro-Tech DS-7
Geophones	T.I.C. 20-cycle and 6-cycle
Drills	1 Failing 740, 1 Carey
Water tankers	2 International 700-gallon, 1 Bedford 700-gallon
Shooting truck	1 Bedford 700-gallon

APPENDIX B

Table of operations

Sedimentary basin	Bowen Basin
Area	Emerald-Duaringa
Camp sites	Near Comet and near Dingo
Established camp	30/7/60
Surveying commenced	1/8/60
Drilling commenced	1/8/60
Shooting commenced	2/8/60
Miles surveyed	95
Topographic survey control	Horizontal and vertical control from main roads bench marks
Total footage	35,536
Explosives used	$8\frac{3}{4}$ tons Geophex and 1092 detonators
Datum level for corrections	500 ft above M.S.L.
Weathering velocities	2000 to 3000 ft/s
Sub-weathering velocities	8000 to 10,500 ft/s
Source of velocity distribution	$t:\Delta t$ analysis and refraction shooting

Reflection shooting data

Shot-point interval	1320 ft
Geophone group	6 per trace at 22-foot intervals (20-cycle geophones)
Geophone group interval	110 ft
Holes shot	250 single and 20 9-hole patterns
Milestraversed	58
Common shooting depths	85 to 105 ft
Usual recording filter	L2H2
Usual playback filter	L2H4
Common charge sizes	20 lb
Weathering corrections	After Vale (1960)
Grading system	Gaby's system (Gaby, 1947)

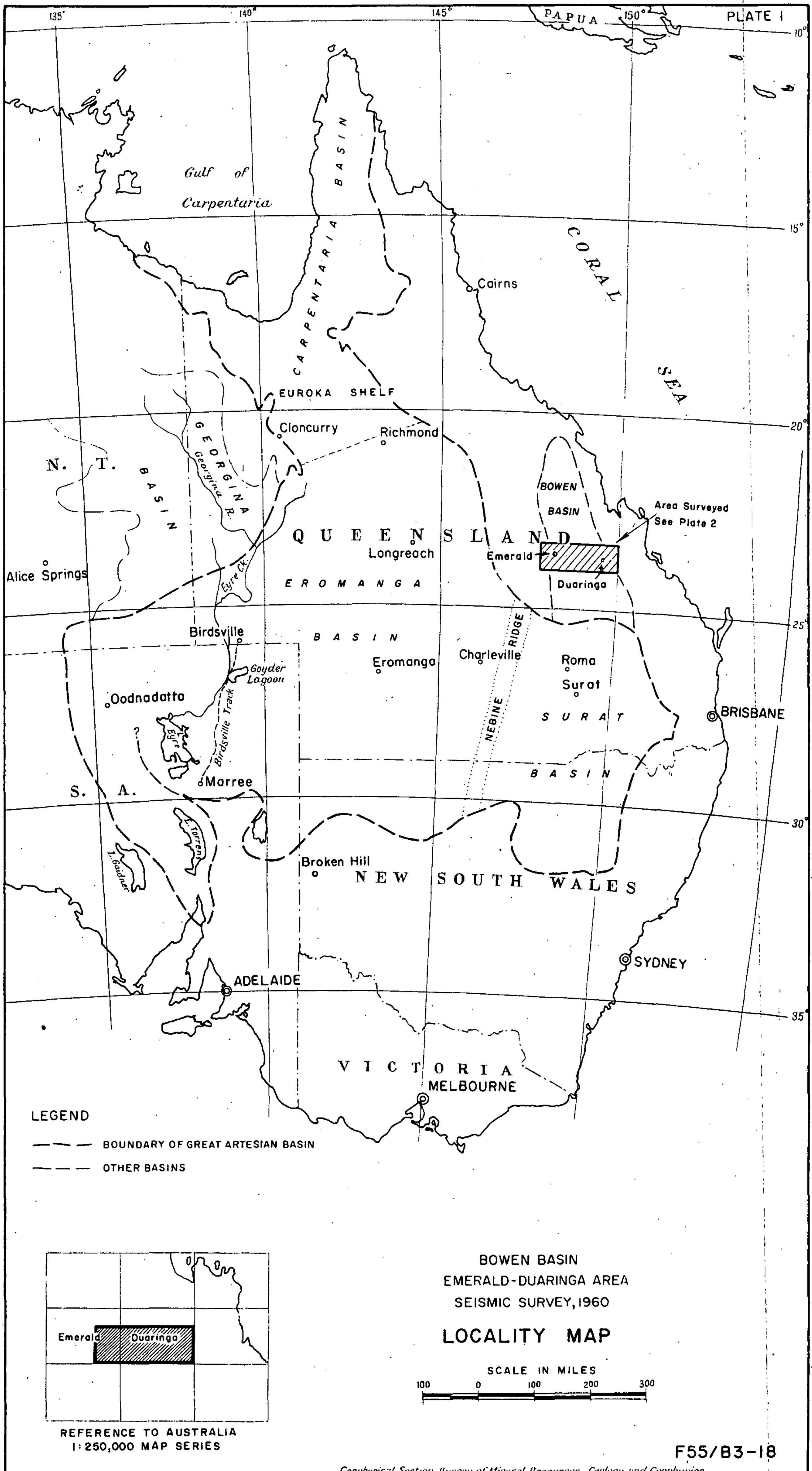
Refraction shooting data

Geophone group	2 6-cycle geophones close together
Geophone group interval	220 ft
Holes shot	39
Usual recording filter	LOH4
Number of refraction traverses	7
Charge sizes	20 to 400 lb
Maximum shot-to-geophone distance	12 miles
Weathering control	From reflection results or weathering spreads
Weathering and elevation corrections	After Vale (1960)

APPENDIX C

Seismic shot-hole drilling

Total footage drilled	35,536
Number of holes drilled	468
Deepest hole	150 ft
Average depth of hole	76 ft

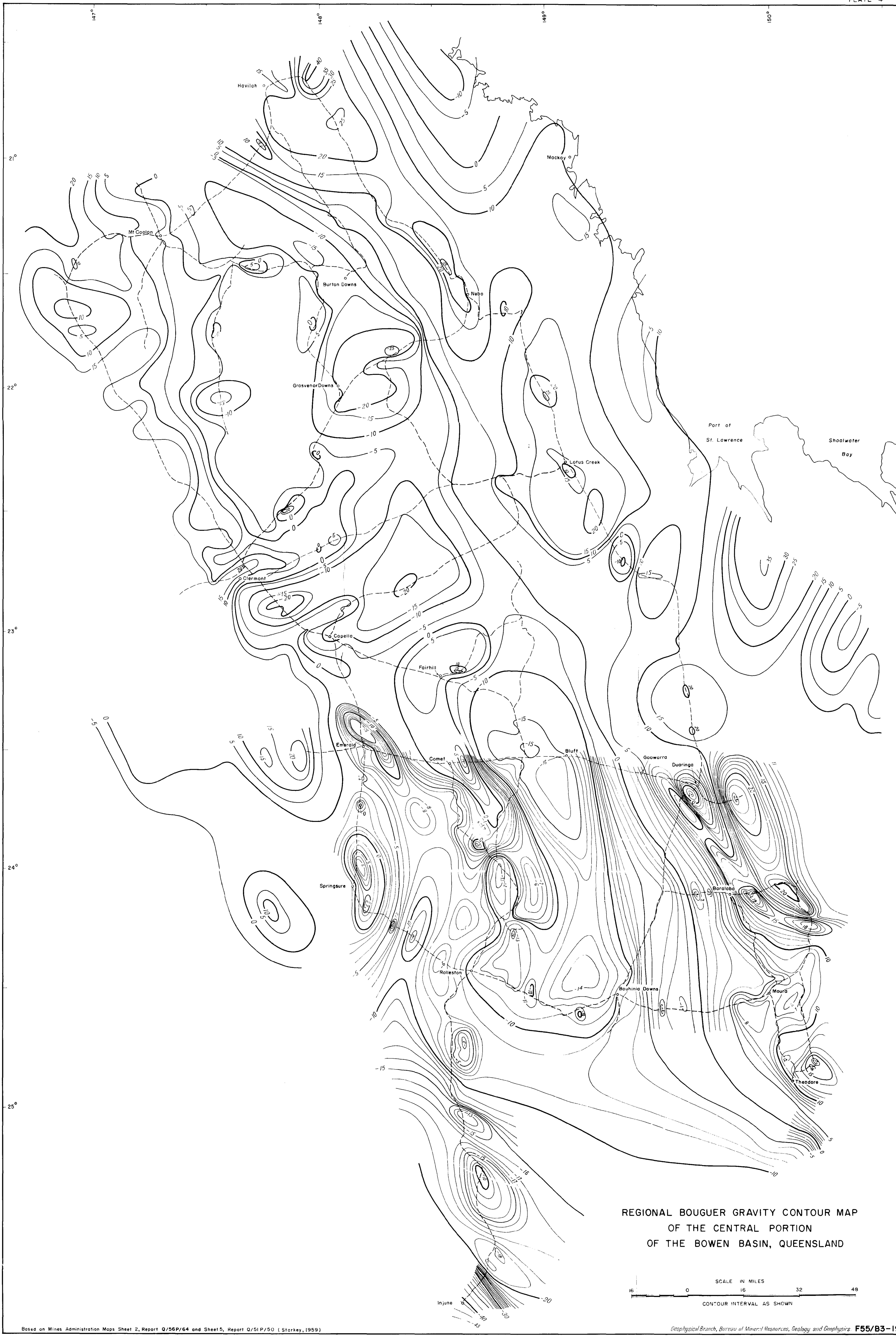


To Accompany Record No. 1965/2


PLATE 2
BOWEN BASIN
EMERALD–DUARINGA AREA
SEISMIC SURVEY, 1960
LAYOUT OF TRAVERSES
LEGEND
SEISMIC REFLECTION TRAVERSE WITH SHOT POINT NUMBERS
RAILWAY
ROAD
TRACK
SCALE IN MILES
METAMORPHICS
UNDIFFERENTIATED
LOWER
PALAEOZOICS
TRAVERSE E
TRAV. H
TRAV. D
TRAVERSE C
TRAV. G
TRAV. B
TRAV. F
TRAVERSE A
TRAV. J
TRAV. K
TRAV. L
TRAV. M
TRAV. N
RIDGE
COMET
INLAND DEFENCE ROAD
MACKENZIE
RIVER
FITZROY
DAWSON
Emerald
Emerald Downs
Anakie
Glendarriwill
Torobarah
Selma
Weemah
Yamala
Comet
Tolmies
Rangal
Blackwater
Bluff
Walton
Umolo
Dingo
Goowarra
Tryphinia
Wallaroo
Duaringa
Bimbah
Boolburra
Edungalba
Ullathorne
Gindie
Kammel
Fernlees
Wurba
Minerva
to Clermont
to Springsure
to Rockhampton
to Banana Downs
True North
Magnetic North
148°00'
148°30'
149°00'
149°30'
23°30'
24°00'
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F55/B3-33
To Accompany Record No. 1965/2

PLATE 3

BRITISH MADE "ALLIANCE"
ANAKIE
TRAVERSE E
TRAV. H
TRAVERSE D
EMERALD
TRAV. C
TRAVERSE C
YAMALA
TRAV. G
COMET
TRAV. B
TRAV. F
BLACKWATER
TRAVERSE A
BLUFF
TRAVERSE J
Umolo
TRAV. K
DINGO
TRAV. L
TRAV. M
DUARINGA
Dawson River
TRAV. N
M.S.L. 0
FEET
Poor reflections only
R.P. reflections with dips steep and erratic
Faulting evident
Poor, steeply dipping events
Dip erratic
Few RP reflections
Poor horizontal reflections 3 to 5 seconds
Poor reflections dips steep and erratic
Horizontal reflections
DIAGRAMMATIC CROSS-SECTION SUMMARISING SEISMIC RESULTS
REFLECTIONS ABLE TO BE CORRELATED FROM RECORD TO RECORD
UNABLE " " " " " "
N.B. REFLECTIONS ARE PLOTTED VERTICALLY BELOW SHOT-POINTS AT WHICH THEY WERE RECORDED
MILLIGALS
REGIONAL BOUGUER ANOMALIES
(AFTER STARKEY, 1959)
'WESTERN FACIES'
(Known from outcrop west and southwest of Emerald)
'EASTERN FACIES'
(Generalised subsurface stratigraphic column from six bores in the Springsure area)
COORQORAH BORE
(A.F.O. No. 1)
Lat. 23°07'30"
Long. 148°42'40"
(Approx. 30 miles north)
COMET-BLACKWATER
(Known from outcrop in the Comet - Mt. Stuart - Bluff Area)
(Derrington & Morgan, 1959 b)
Lower Permian
Colinlea Formation
Possibly present
Lower Permian - Carboniferous
Carboniferous
Devonian
STRATIGRAPHY - KNOWN OR EXPECTED
ANAKIE STRUCTURAL HIGH
'CARNARVON TROUGH'
COMET RIDGE
INTERMEDIATE ZONE
DAWSON TECTONIC ZONE
Metamorphics outcrop
Colinlea outcrops
Permian
Metamorphics
Metamorphics?
Tertiary
DEPTH IN FEET
POSSIBLE CROSS-SECTION
HORIZONTAL SCALE 21,120 FEET : 1 INCH
VERTICAL " " 20,000 " : 1 "



To Accompany Record No. 1965/2

PLATE 6
MILLISECONDS
REFRACTION TRAVERSE A
SCALE
SURFACE ELEVATION
BASE OF WEATHERED LAYER
DATUM
FEET A.S.L.
FEET BELOW DATUM
PROFILES OF REFRACTORS SHOWING RAY PATHS
HORIZONTAL SCALE 1 INCH : 2000 FEET
VERTICAL SCALE 1 INCH : 2000 FEET
F55/83-25


Milliseconds
S.P. 122
S.P. 205
S.P. 148
S.P. 104
Δt - DIP ELEMENT IN REFRACTOR VELOCITY V₂
Δt - DIP ELEMENT IN REFRACTOR VELOCITY V₃
FEET A.S.L.
DATUM
SURFACE ELEVATION
BASE OF WEATHERED LAYER
FEET BELOW DATUM
PROFILES OF REFRACTORS SHOWING RAY PATHS
HORIZONTAL SCALE 1 INCH : 2200 FEET
VERTICAL SCALE 1 INCH : 2000 FEET
BOWEN BASIN
SEISMIC SURVEY
REFRACTION TRAVERSE C
F55/B3-28

PLATE 7

S.P. 520

	180												182											184
t_o	3027	3015	3005	2994	2976	2971	2963	2946	2933	2920	2907	×	—	2865	2845	2840	2818	2808	2798	2784	2777	2766	2756	2748	2733
W_c+E_c	113	114	115	116	117	116	120	118	116	115	114	112	—	111	111	111	110	110	110	109	108	109	108	107	105
t_c	2915	2901	2890	2878	2859	2853	2843	2828	2818	2805	2793	×	—	2754	2734	2724	2708	2698	2688	2675	2671	2657	2648	2641	2622

S.P. 542

	182												184											186
t_o	2274	2290	2297	2320	2330	2345	2365	2375	2392	2407	2423	2437	—	2477	2488	2509	2529	2546	2566	2583	2597	2611	2621	2645	2661
W_c+E_c	131	131	130	130	129	128	128	127	126	126	125	123	—	123	124	125	126	126	127	127	129	130	130	131	132
t_c	2143	2159	2167	2190	2201	2217	2237	2248	2266	2281	2298	2314	—	2354	2364	2383	2403	2420	2439	2456	2468	2481	2491	2514	2529

REFRACTION TRAVERSE D

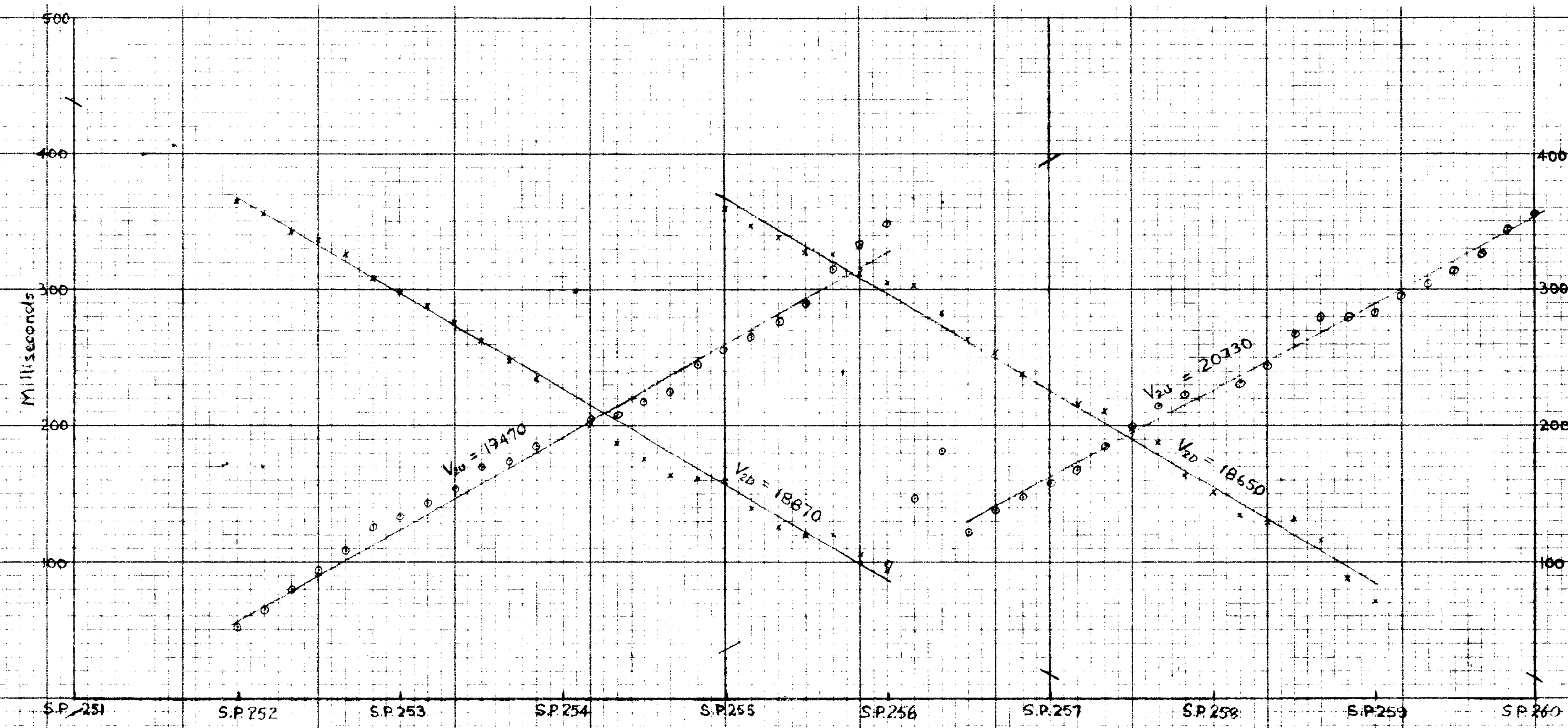
SCALE

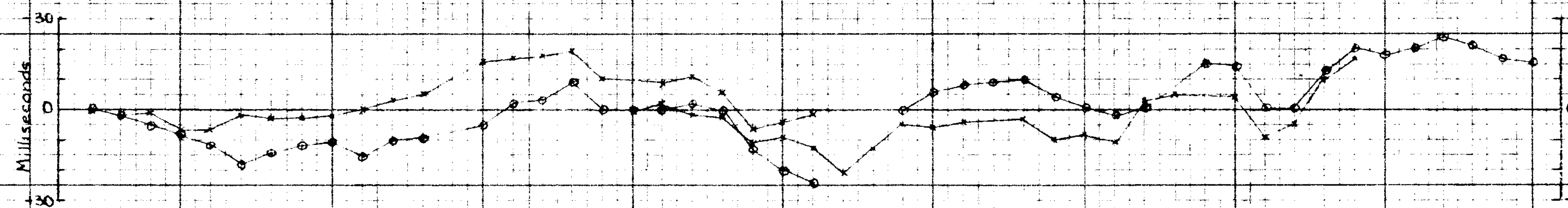
VERTICAL — FEET
HORIZONTAL — FEET

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

To Accompany Record No 1965/[illegible]

F55/B3-27





Δt – DIP ELEMENT IN REFRACTOR VELOCITY V_2

S.P. 251 / S.P. 255

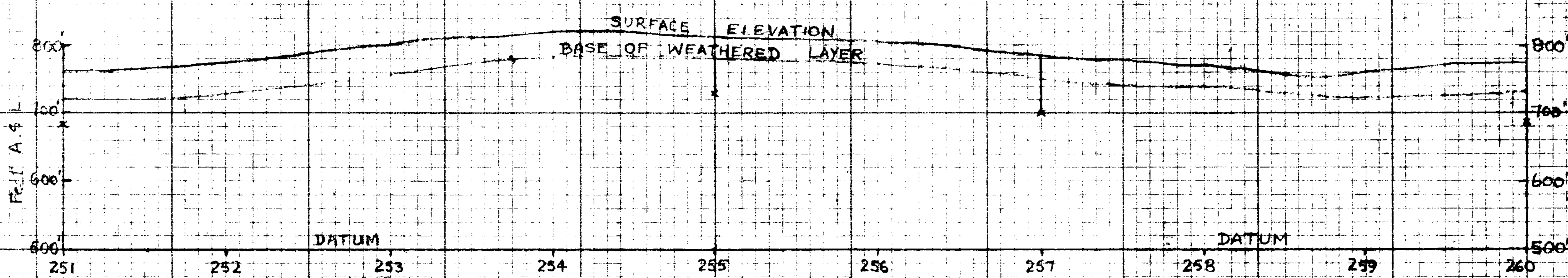
S.P.	252												254												256
t_o	145	156	174	189	204	223	236	239	250	266	270	281	–	299	304	314	319	339	349	360	370	383	405	423	438
E_c+W_c	93	93	94	95	95	96	96	96	96	96	95	95	–	95	95	95	94	94	93	93	93	93	90	90	90
t_c	52	65	80	94	109	127	134	[illegible]	154	170	175	186	–	204	209	219	225	245	256	267	277	290	315	333	348

S.P.	256												258												260
t_o	113	160	196	218	235	245	254	265	280	294	307	314	–	322	335	359	371	371	376	390	400	408	423	441	454
E_c+W_c	94	94	95	96	96	97	96	96	94	94	92	91	–	91	91	91	91	92	93	93	95	95	96	98	98
t_c	99	146	181	122	139	148	159	169	186	200	215	223	–	234	244	268	280	279	283	297	305	313	327	343	356

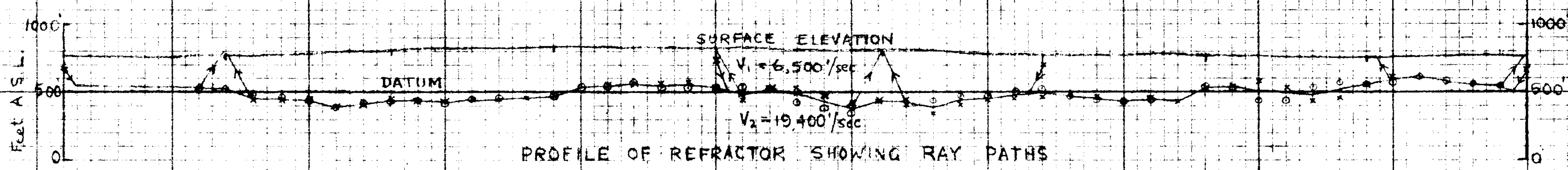
S.P. 257 / S.P. 260

S.P.	252												254												256
t_o	463	454	442	438	427	411	401	390	377	364	349	335	–	302	289	277	263	261	259	239	225	219	216	209	189
E_c+W_c	99	99	100	101	101	102	102	102	102	102	101	101	–	101	101	101	100	100	99	99	99	99	96	96	96
t_c	364	355	342	337	326	309	299	288	275	262	248	234	–	201	188	176	163	161	160	140	126	120	120	107	93

S.P.	255												257												259
t_o	454	444	432	422	418	403	396	392	373	354	344	330	–	306	300	286	276	250	237	219	215	216	201	177	159
E_c+W_c	94	94	94	94	91	91	91	90	91	91	91	91	–	90	89	88	87	86	86	85	86	85	86	88	88
t_c	360	347	338	328	327	312	305	302	282	263	253	239	–	216	211	198	189	164	151	134	129	131	115	89	71



REFRACTION TRAVERSE E



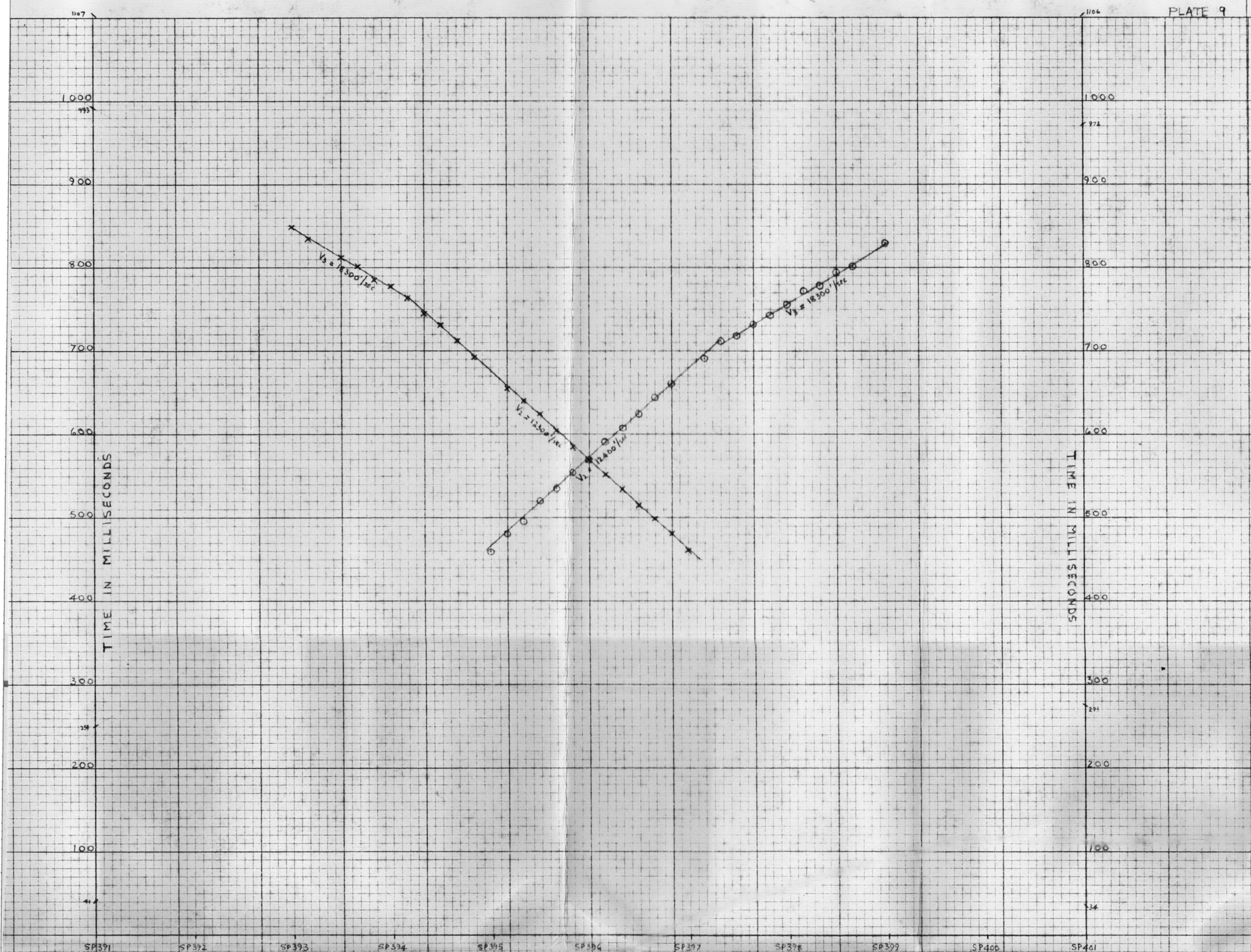
PROFILE OF REFRACTOR SHOWING RAY PATHS

HORIZONTAL SCALE 1 INCH : 1100 FEET

VERTICAL SCALE 1 INCH : 1000 FEET

F55/B3-28

PLATE 9



SP391

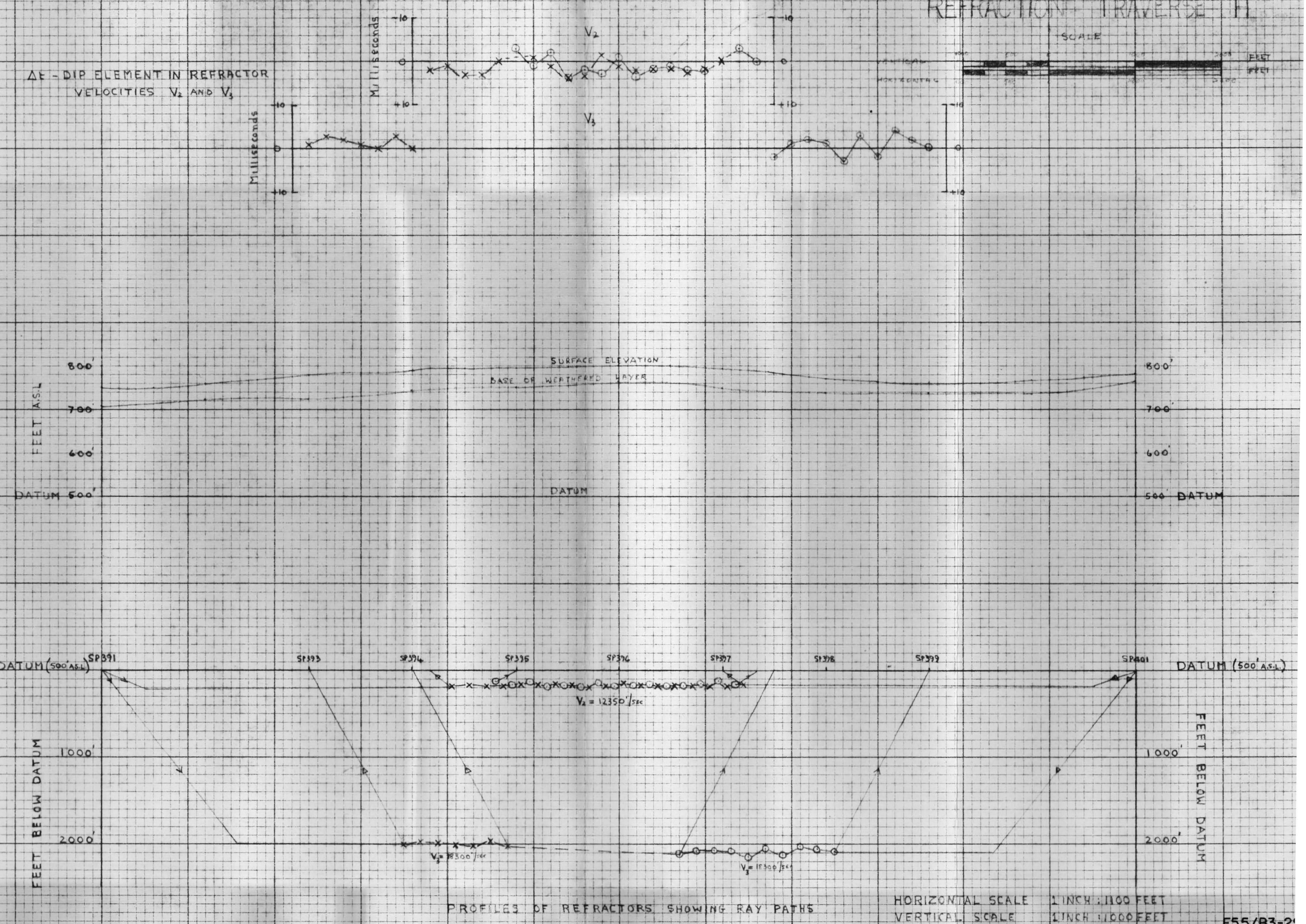
546	567	581	605	620	639	653	676	693	710	729	748	–	776	796	806	819	827	840	855	860	876	881	–	907	t_o
86	84	85	85	84	84	84	85	86	86	86	87	–	85	84	88	87	84	84	83	82	81	80	80	78	$W_c + E_c$
460	482	476	520	536	555	569	591	607	624	643	661	–	671	712	718	732	743	756	772	778	795	801	–	829	t_c

SP401

	393												395												397
t_o	943	929	–	907	876	880	871	853	834	819	801	781	–	744	728	713	693	670	656	639	622	604	587	570	549
$W_c + E_c$	94	94	94	94	94	93	93	88	88	86	88	88	–	85	88	88	87	86	87	87	88	88	88	89	88
t_c	849	835	–	813	802	787	778	765	746	731	713	693	–	656	640	625	606	584	569	552	534	516	499	481	461

REFRACTION TRAVERSE H

Δt - DIP ELEMENT IN REFRACTOR VELOCITIES V_2 AND V_3



PROFILES OF REFRACTORS SHOWING RAY PATHS

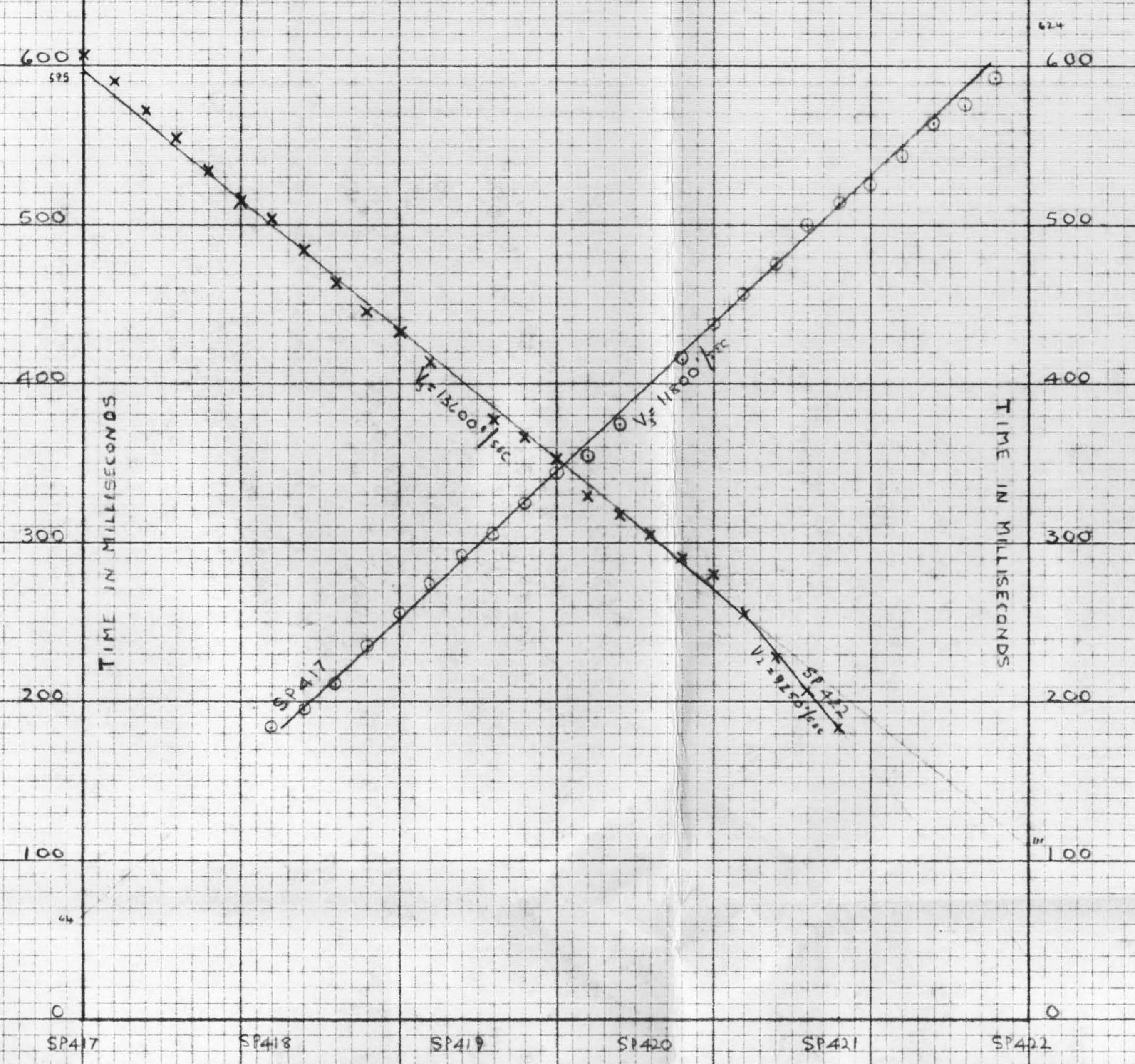
HORIZONTAL SCALE 1 INCH : 1100 FEET
VERTICAL SCALE 1 INCH : 1000 FEET

F55/B3-2

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

To accompany Record No. 1965/2

BRITISH MADE "ALLIANCE"

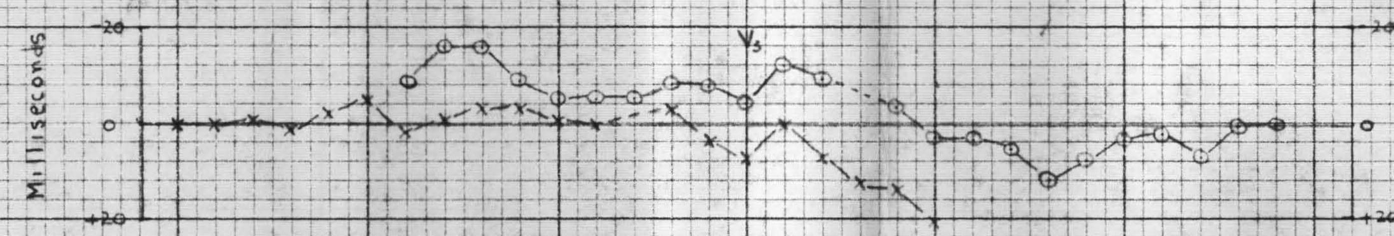


SP 417

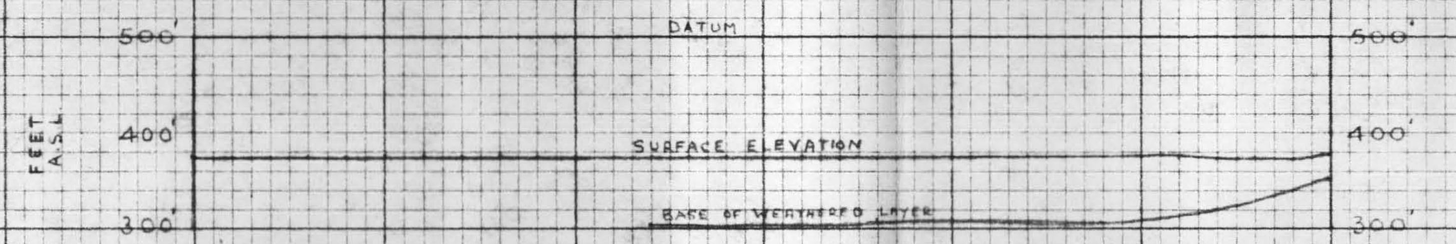
418												420												422	
149	161	177	201	223	239	258	273	290	310	320	339	–	380	403	423	440	465	480	492	500	526	536	551	–	t_o
34	34	34	34	34	34	33	33	34	34	34	35	–	35	35	34	34	34	33	34	36	38	39	41	42	$W_c + E_c$
183	195	211	235	257	273	291	306	324	344	354	374	–	415	438	457	476	499	513	526	542	566	575	592	–	t_c

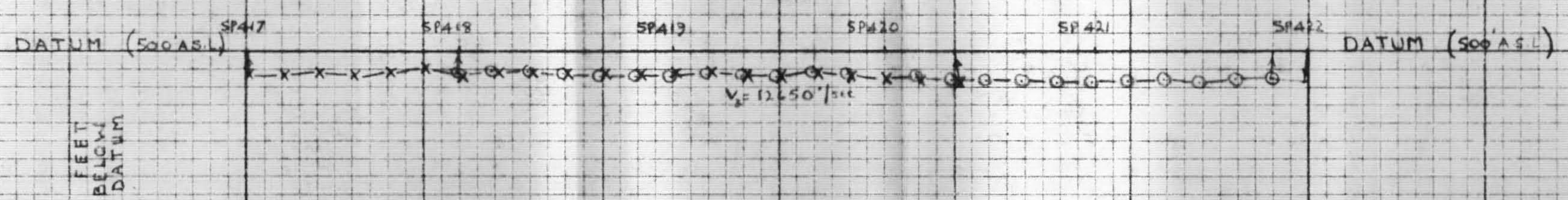
	417												419												421
t_o	573	556	537	522	501	481	470	450	431	413	398	382	–	345	333	319	295	283	271	256	245	232	206	184	162
$W_c + E_c$	34	34	34	34	34	34	34	34	34	34	34	34	–	33	34	34	34	35	35	35	35	25	25	25	24
t_c	607	590	571	556	535	515	504	484	465	447	432	416	–	378	367	353	329	318	306	291	280	257	229	209	186

SP 422



Δt – DIP ELEMENT IN REFRACTOR
VELOCITY V_3



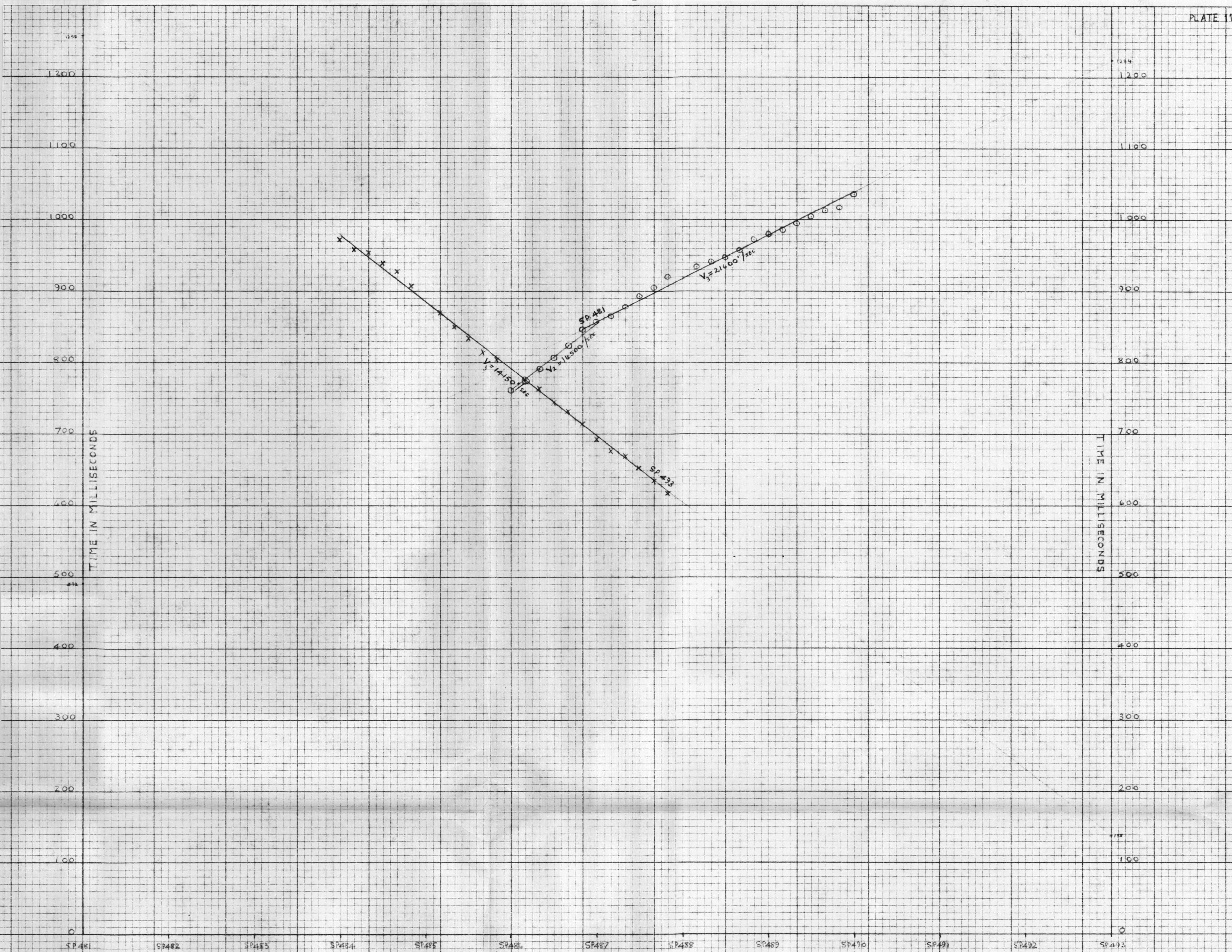


PROFILE OF REFRACTOR SHOWING RAY PATHS

HORIZONTAL SCALE 1 INCH : 1100 FEET
VERTICAL SCALE 1 INCH : 1000 FEET

REFRACTION TRAVERSE K

SCALE



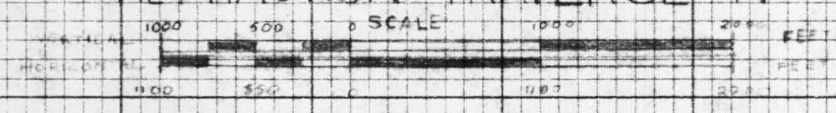
SP481

484												488												490	
731	742	762	776	792	805	816	823	836	850	861	876	–	891	899	907	918	935	942	949	957	968	977	980	1000	t_o
31	31	31	32	32	42	42	42	42	43	43	44	–	43	42	41	40	38	38	38	38	37	37	37	37	$W_c + E_c$
762	773	793	808	824	847	858	865	878	893	904	920	–	934	941	948	958	973	980	987	995	1005	1014	1017	1037	t_c

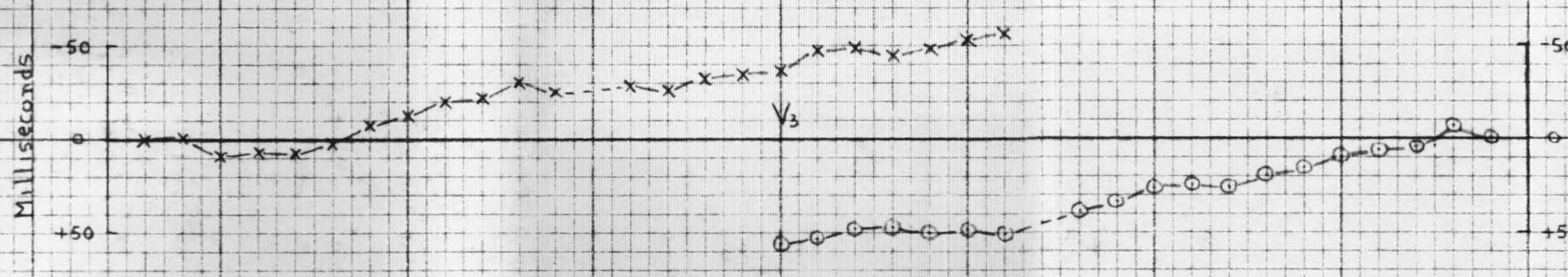
SP 493

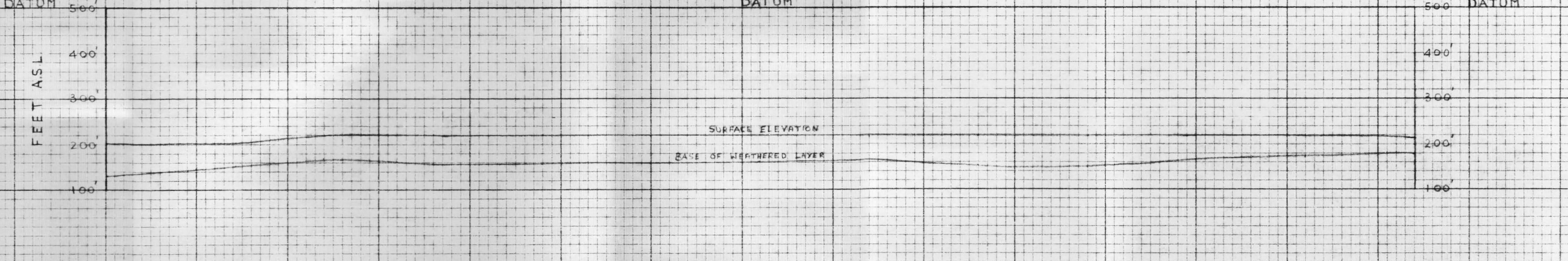
	484											486												488
t_o	933	918	915	899	887	868	–	829	809	793	772	763	–	734	723	703	689	673	650	635	626	610	591	574	547
$W_c + E_c$	40	40	40	41	41	41	41	41	41	42	42	42	–	42	42	43	43	43	43	43	43	44	44	45	–
t_c	973	958	955	940	928	909	–	870	850	835	814	805	–	776	765	746	732	716	693	678	669	654	635	619	–

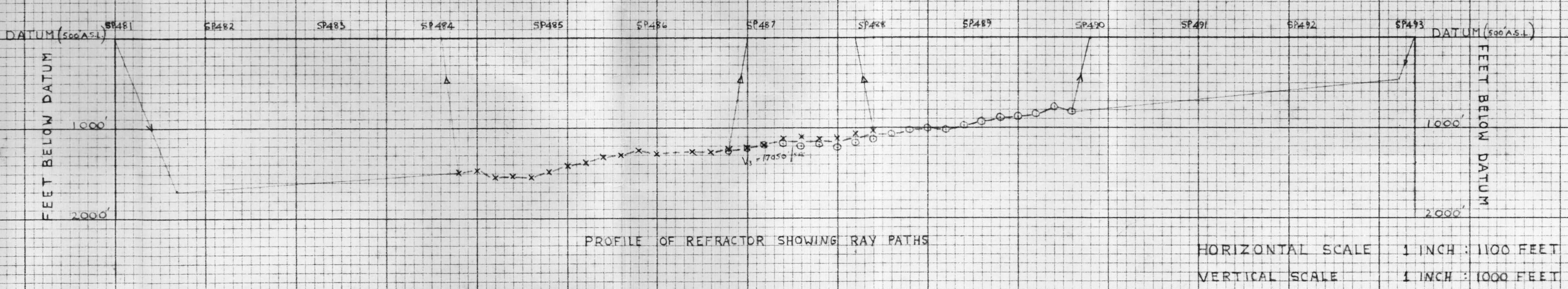
REFRACTION TRAVERSE N



ΔE - DIP ELEMENT IN REFRACTOR VELOCITY V_3





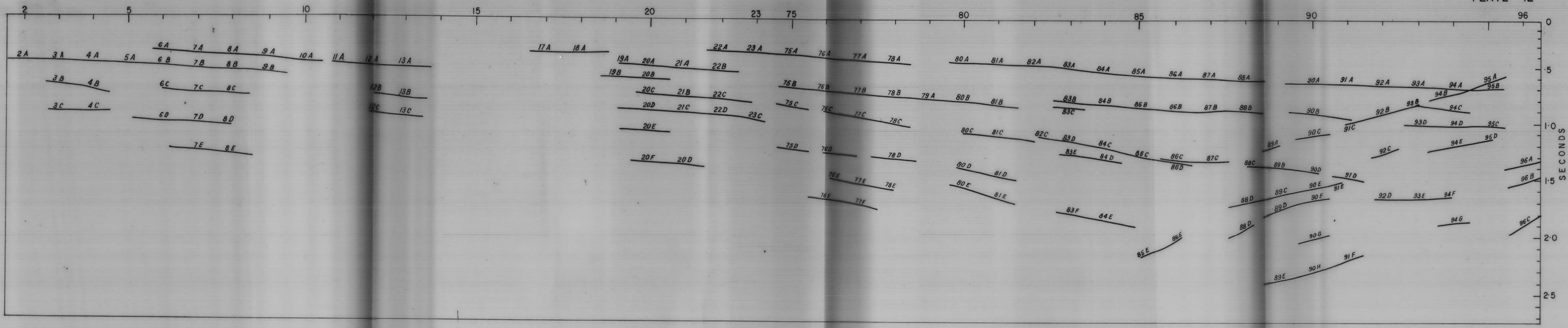


PROFILE OF REFRACTOR SHOWING RAY PATHS

HORIZONTAL SCALE	1 INCH	1100 FEET
VERTICAL SCALE	1 INCH	1000 FEET

EMERALD [illegible] AREA [illegible]

PLATE 12



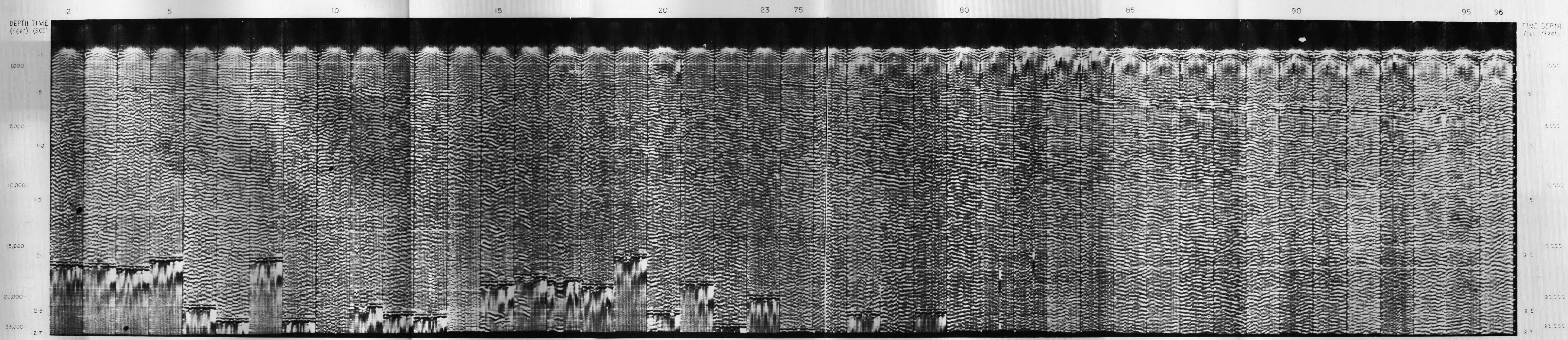
REFLECTION TRAVERSE A, OVERLAY FOR VARIABLE-INTENSITY CROSS-SECTION

(REFLECTIONS MARKED BY LETTERS ARE SHOWN IN MIGRATED POSITIONS ON PLATE 14)

EMERALD DUARINGA SEISMIC S. 1960

To Accompany Record No. 1965/2

OVERLAY ON F 55/B3-1-1



BOWEN BASIN

VARIABLE - INTENSITY CROSS - SECTION

TRAVERSE A

HORIZONTAL SCALE IN MILES

0 1/4 1/2 1 1 1/2 2

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics
To Accompany Record No. 1965/2

F 55/B3-1-1

PLATE 14

REFLECTION TRAVERSE A

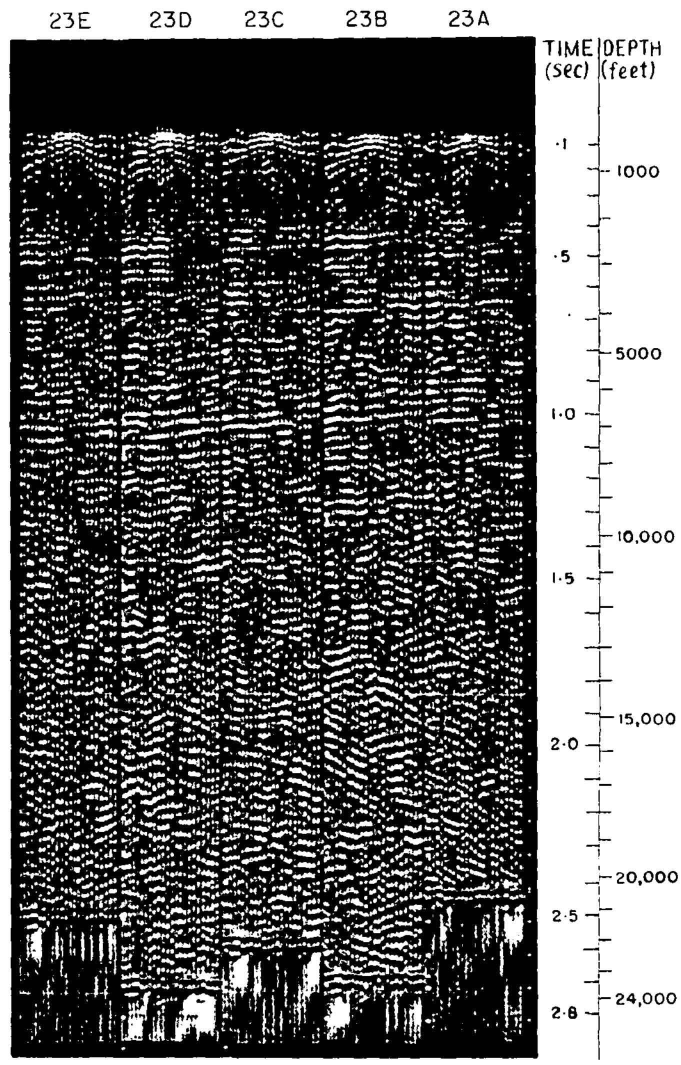
"MIGRATED" CROSS - SECTION

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F55/B3-22

To Accompany Record No.1965/2

EMERALD DUARINGA SEISM. S. QLD. 1960

PLATE 15



BOWEN BASIN

VARIABLE-INTENSITY CROSS-SECTION

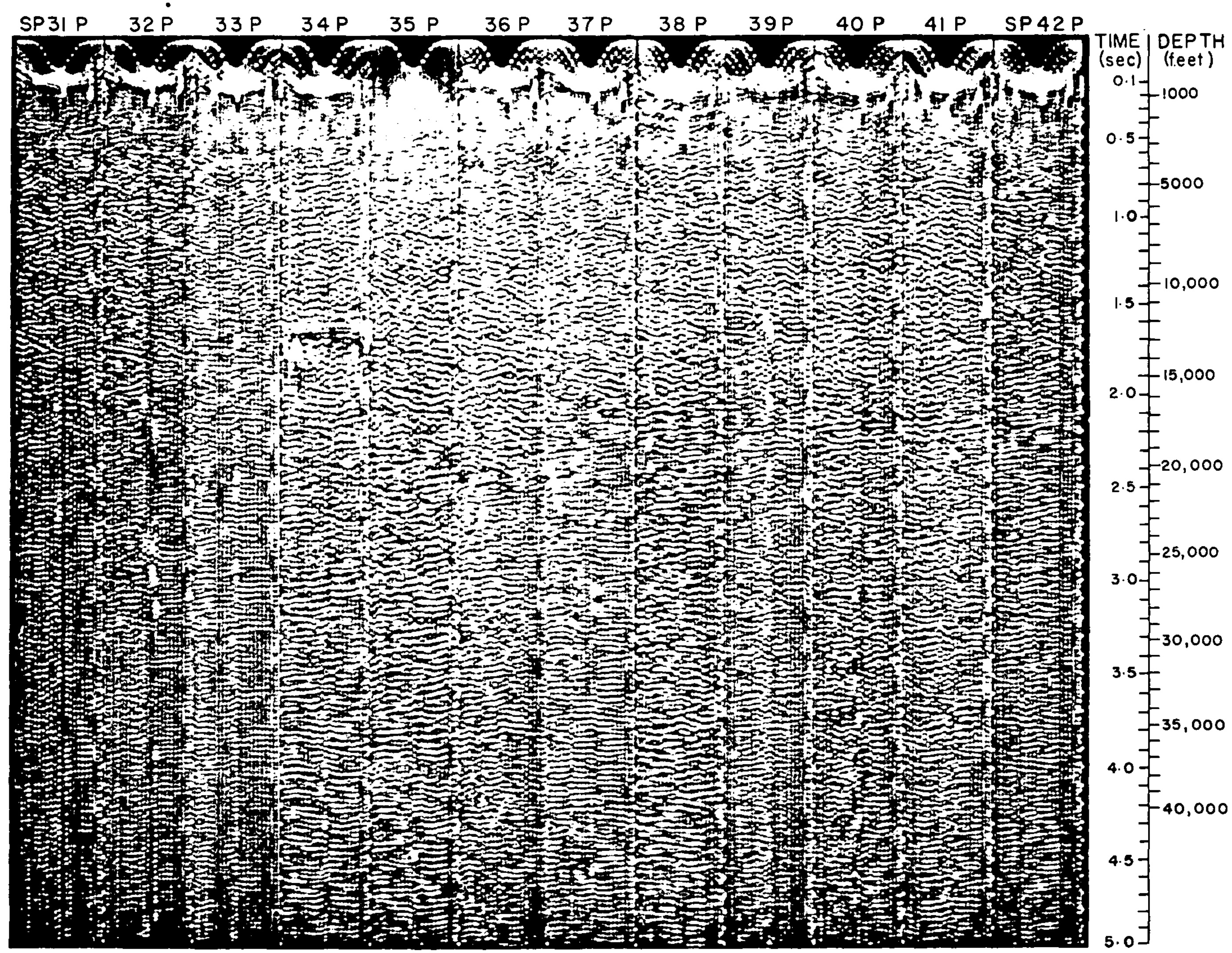
TRAVERSE XA

HORIZONTAL SCALE IN MILES

0 ¼ ½ 1

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F55/B3-9-1

To Accompany Record No.1965/2



VARIABLE - INTENSITY CROSS - SECTION

TRAVERSE B

HORIZONTAL SCALE IN MILES

0 1/4 1/2 1

PLATE 16

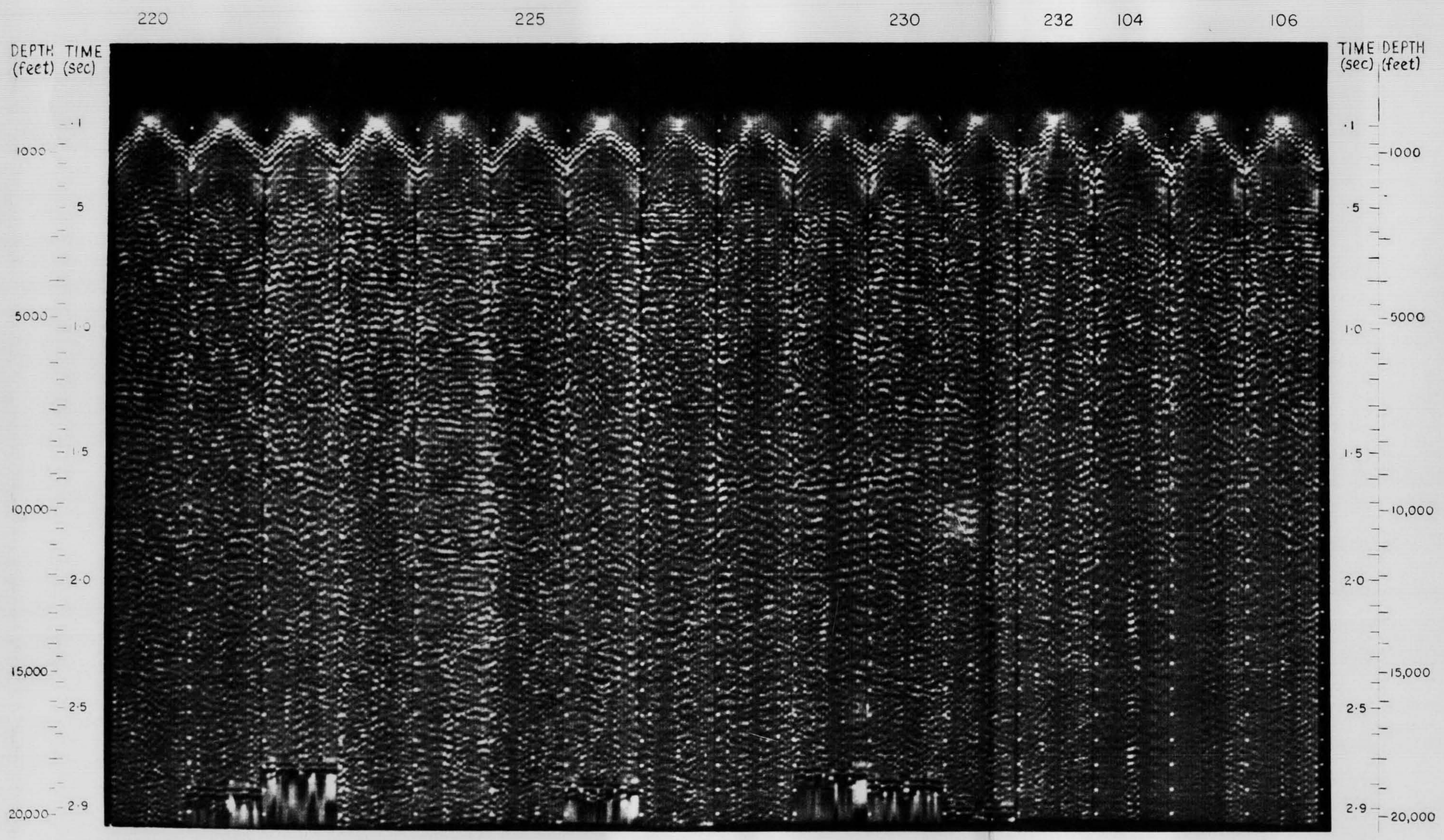
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

To Accompany Record No. 1965/2

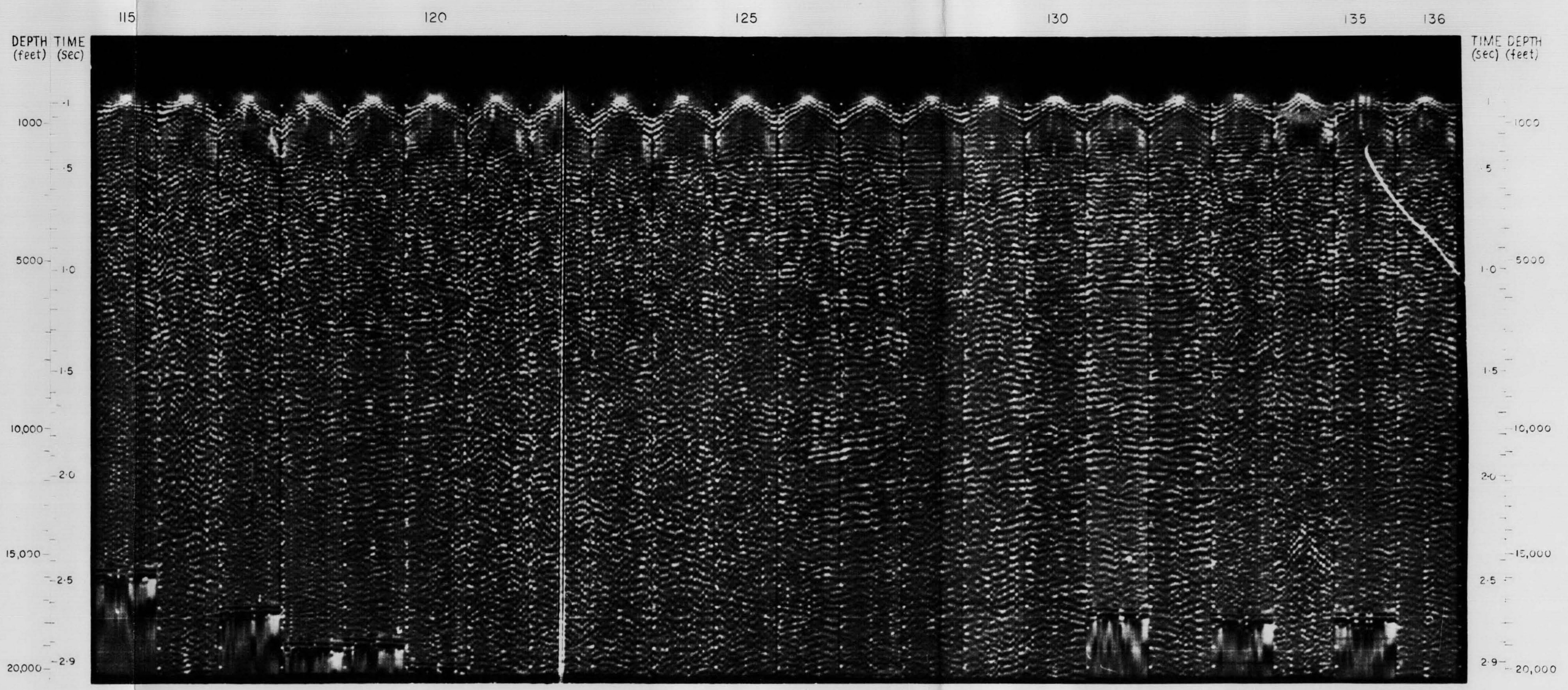
F55/B3-11-1

PLATE 17

BOWEN BASIN



REFLECTION TRAVERSE C
VARIABLE-INTENSITY CROSS-SECTION



VARIABLE-INTENSITY CROSS-SECTION

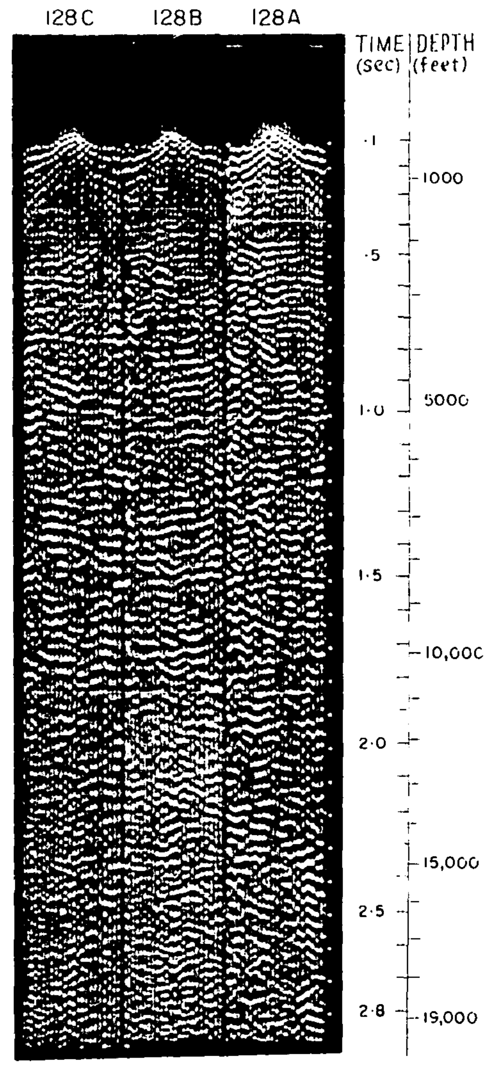
TRAVERSE C

HORIZONTAL SCALE IN MILES

0 1/4 1/2 1 1 1/2 2

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics
To Accompany Record No. 1965/2

F55/B3-2-1



BOWEN BASIN

VARIABLE-INTENSITY CROSS-SECTION

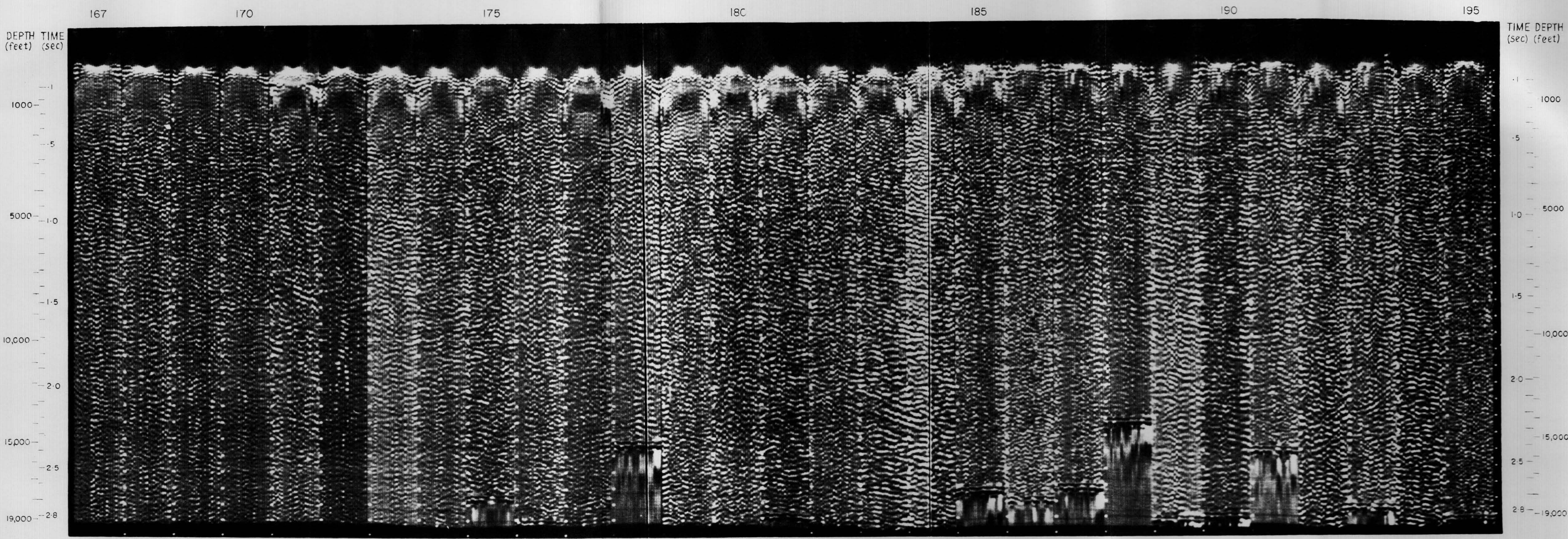
TRAVERSE XC

HORIZONTAL SCALE IN MILES

0 1/4 1/2 1

Geophysical Branch, Bureau of Mineral Resources Geology and Geophysics F55/B3-10-1

To Accompany Record No. 1965/2



BOWEN BASIN

VARIABLE - INTENSITY CROSS - SECTION

TRAVERSE D

HORIZONTAL SCALE IN MILES

0 1/4 1/2 1 1 1/2 2

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F55/B3-3-1

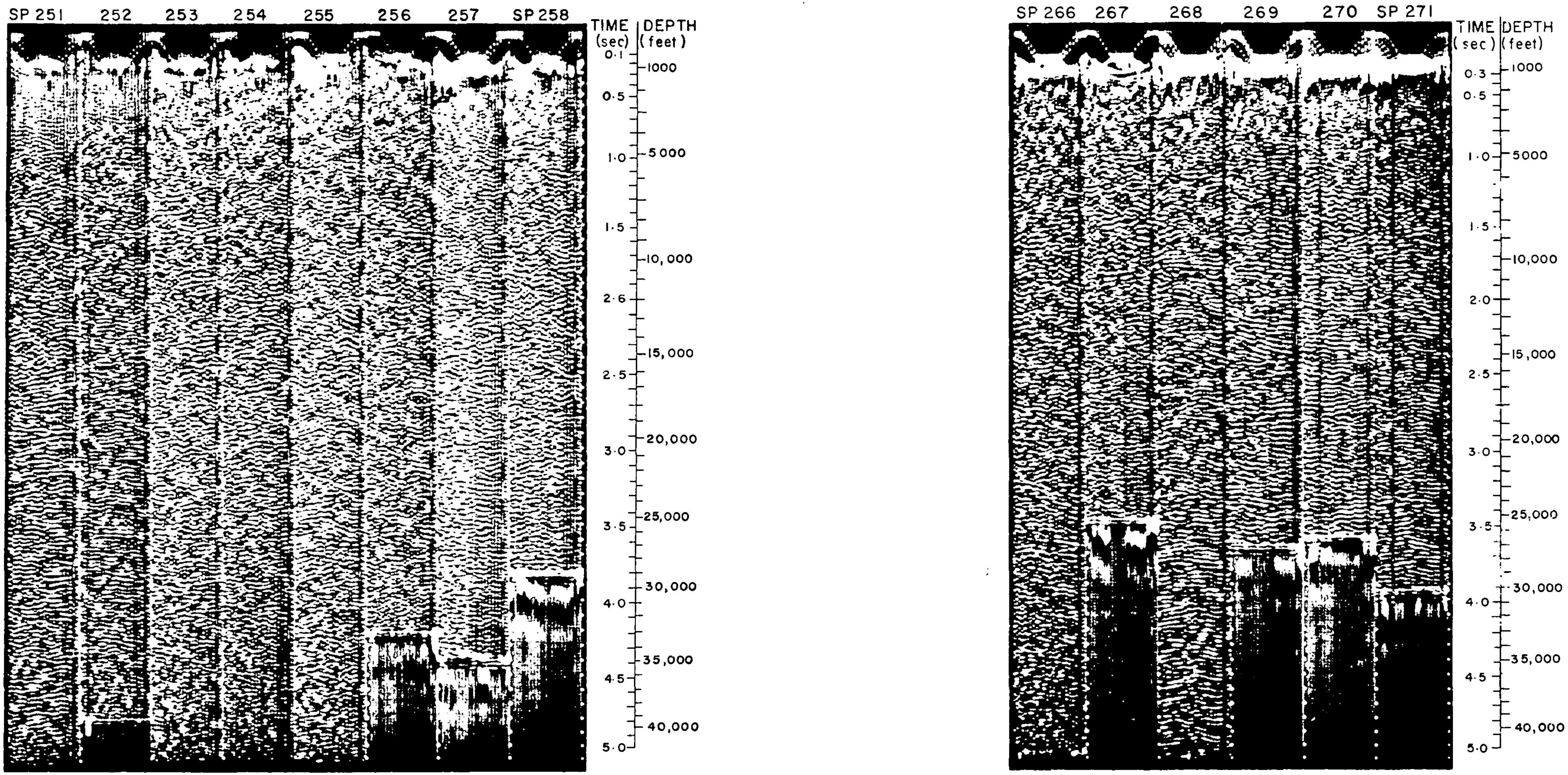
To Accompany Record No. 1965/2

BOWEN BASIN QLD 1961

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

To Accompany Record No.1965/2

F 55/B3-12-1



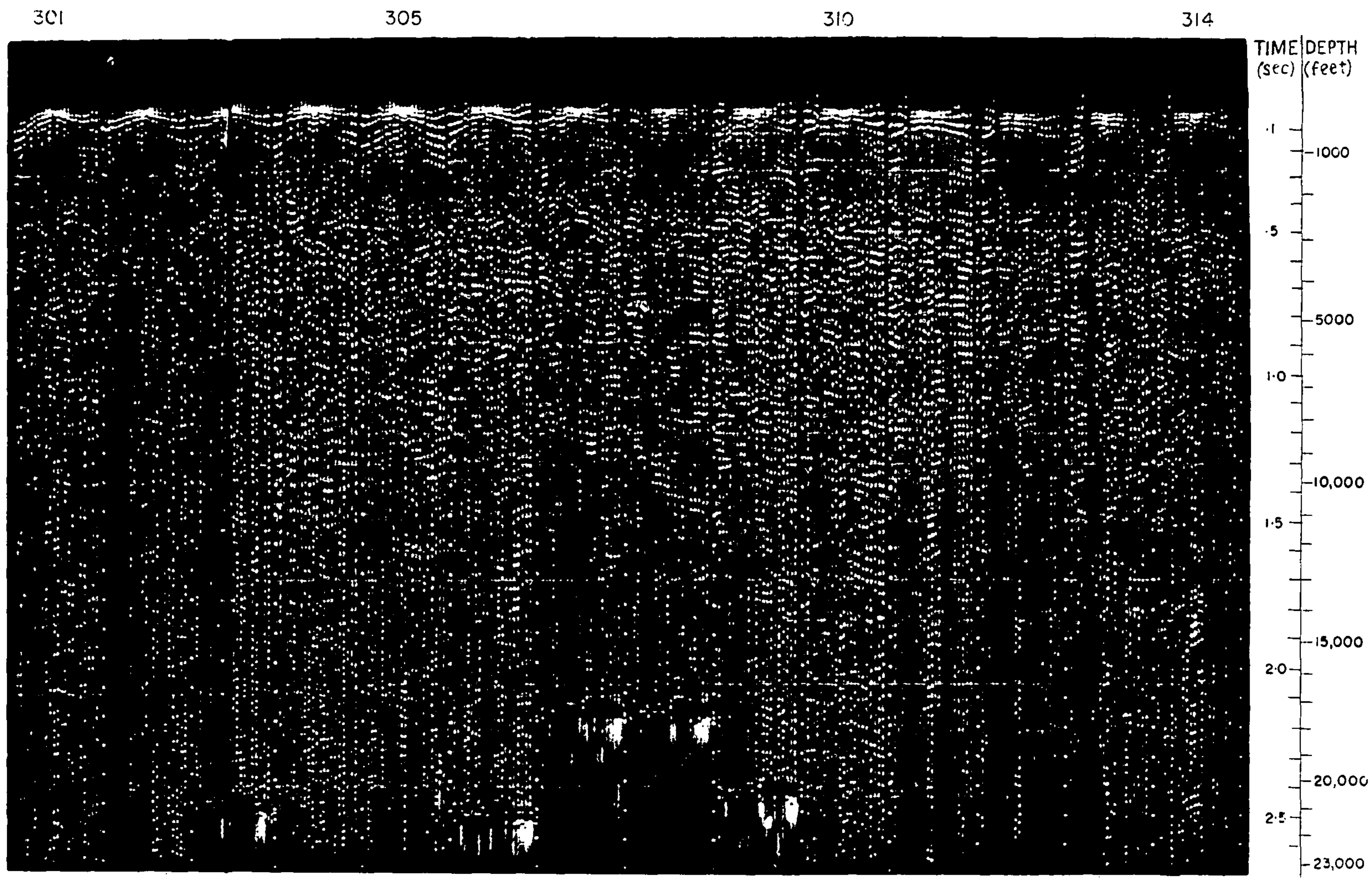
VARIABLE-INTENSITY CROSS-SECTION

TRAVERSE E

HORIZONTAL SCALE IN MILES

0 ¼ ½ 1

PLATE 20



VARIABLE - INTENSITY CROSS - SECTION

TRAVERSE F

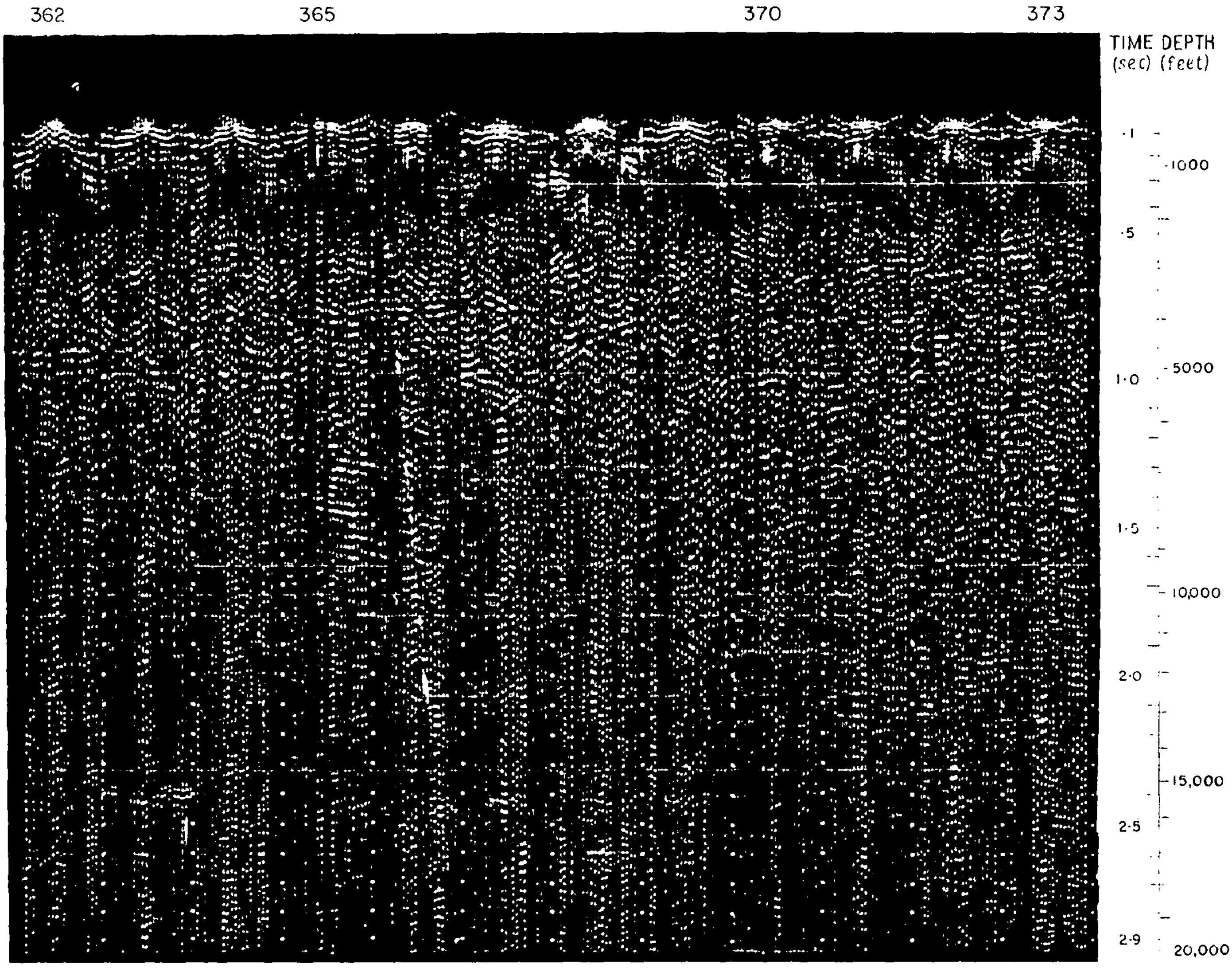
HORIZONTAL SCALE IN MILES

0 1/4 1/2 1

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

To Accompany Record No.1965/2

F55/B3-4-1



VARIABLE-INTENSITY CROSS-SECTION

TRAVERSE G

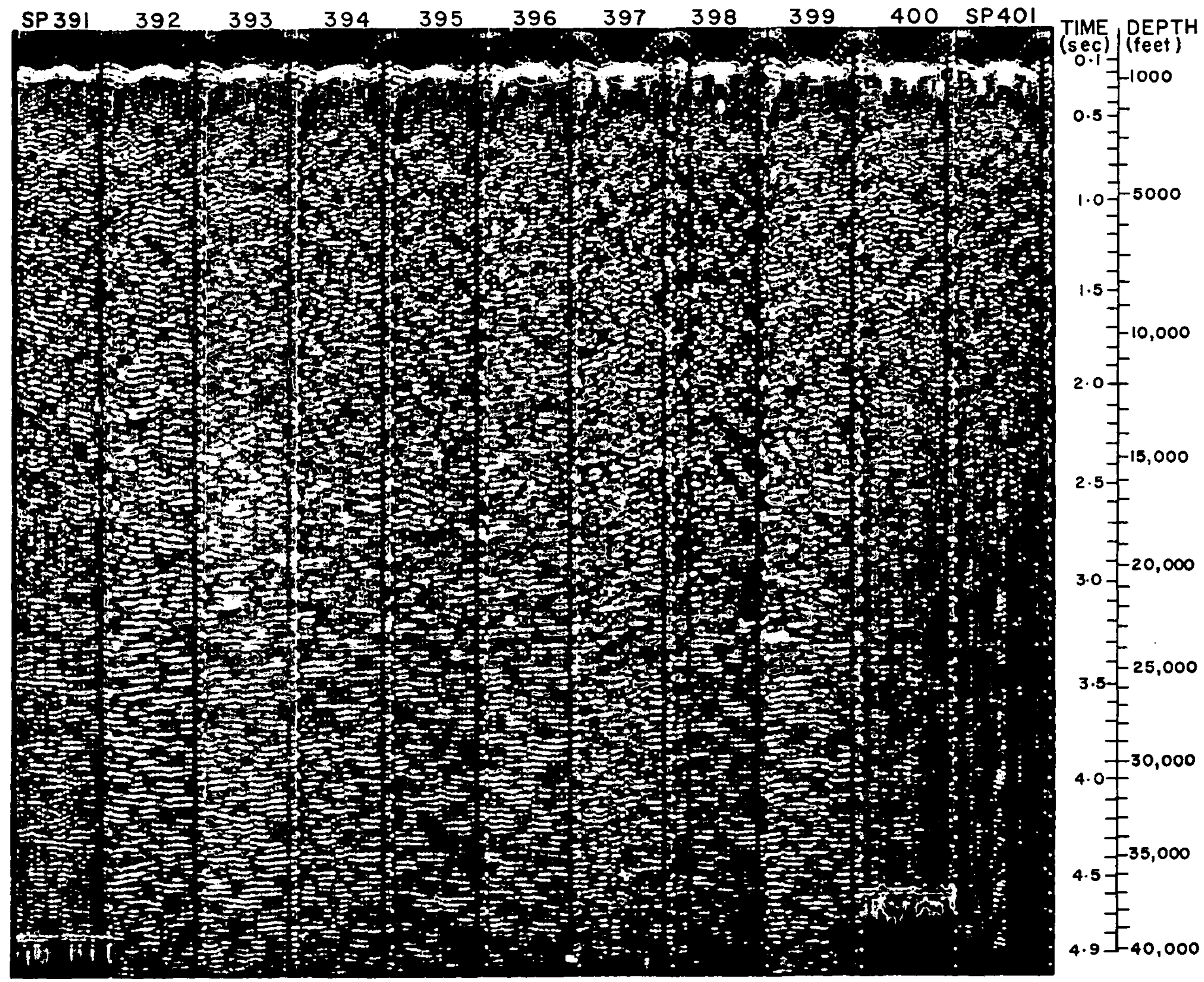
HORIZONTAL SCALE IN MILES

0 1/4 1/2 1

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

To Accompany Record No.1965/2 F 55/B3-5-1

BOWEN BASIN QLD 1961



VARIABLE - INTENSITY CROSS-SECTION

TRAVERSE H

HORIZONTAL SCALE IN MILES

0 ¼ ½ 1

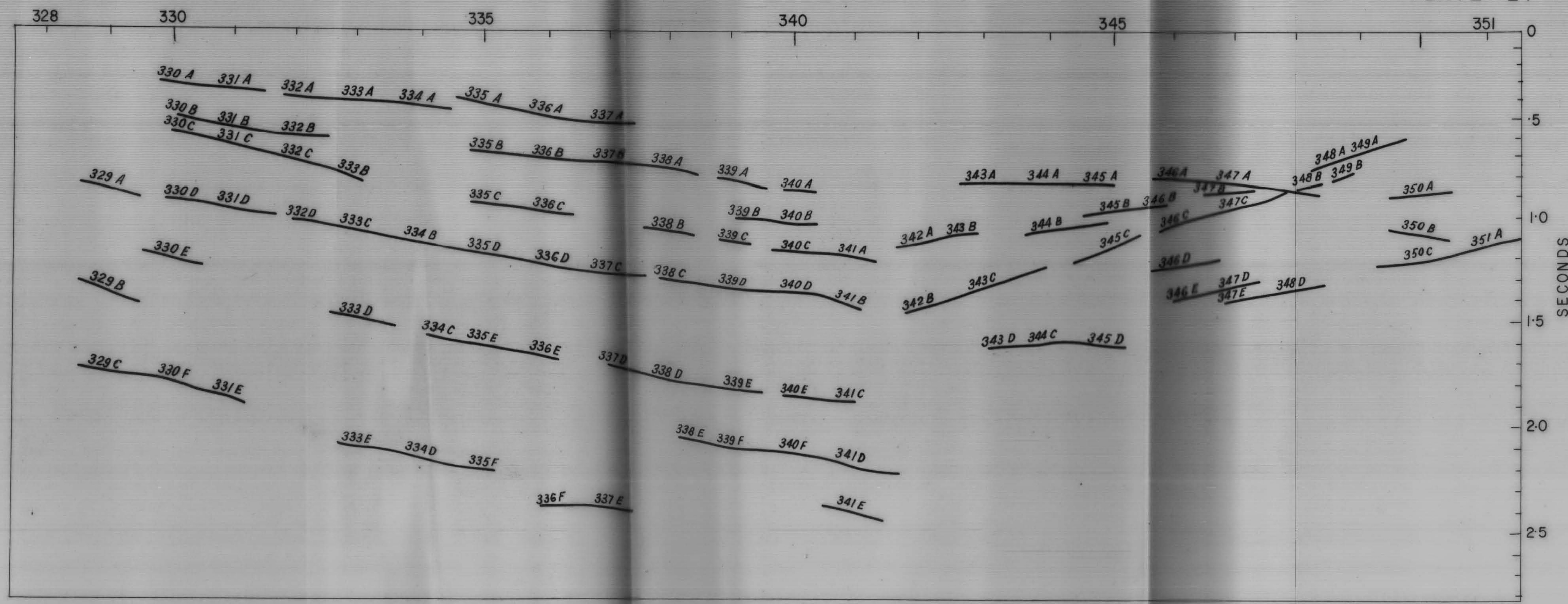
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

To Accompany Record No 1965/2

F55/B3-13-1

PLATE 23

PLATE 24



REFLECTION TRAVERSE J, OVERLAY FOR VARIABLE-INTENSITY CROSS-SECTION

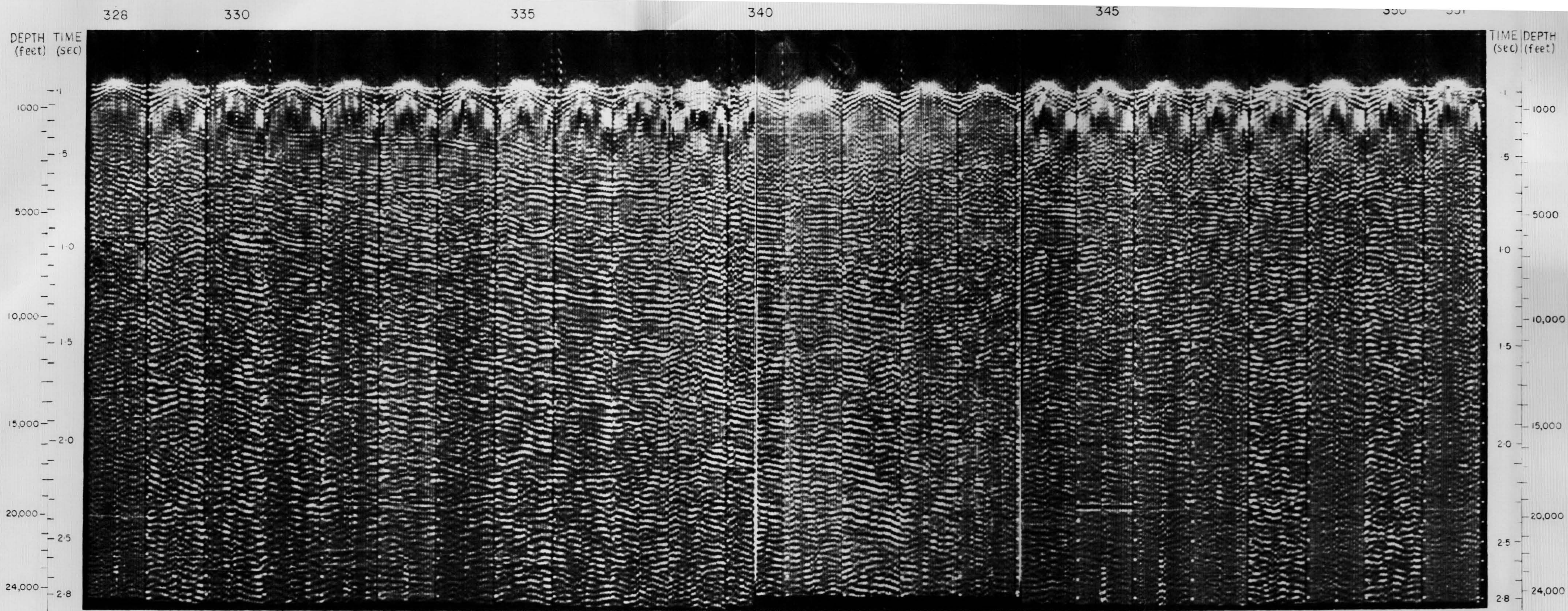
(REFLECTIONS MARKED BY LETTERS ARE SHOWN IN MIGRATED POSITIONS ON PLATE 26)

EMERALD DUARINGA SEISM. S. 1960

To Accompany Record No. 1965/2

OVERLAY TO F55/B3-6-1

BOWEN BASIN



VARIABLE - INTENSITY CROSS - SECTION

TRAVERSE J

HORIZONTAL SCALE IN MILES.

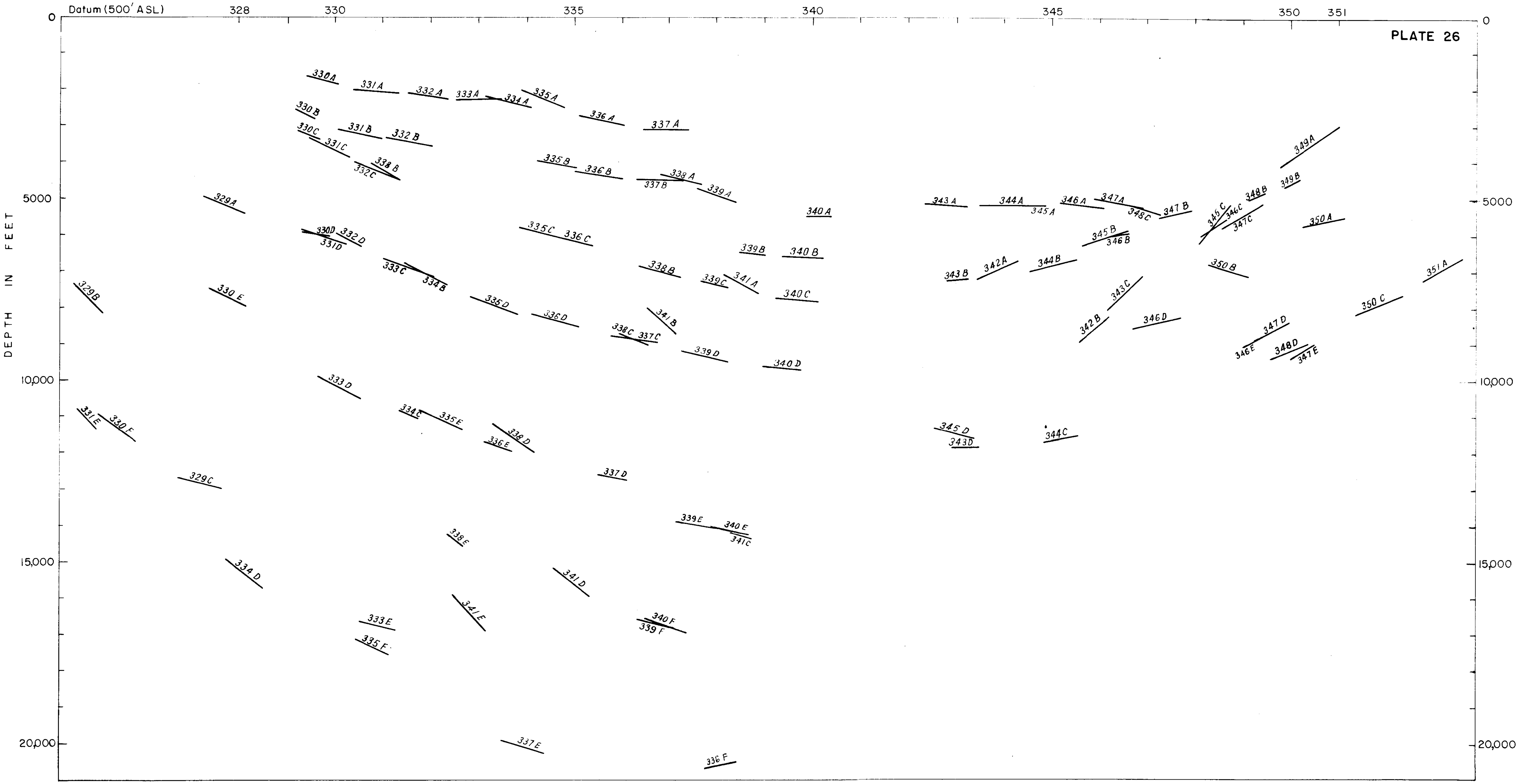
0 1/4 1/2 1 1 1/2 2

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

To Accompany Record No. 1965/2

F55/B3-6-1

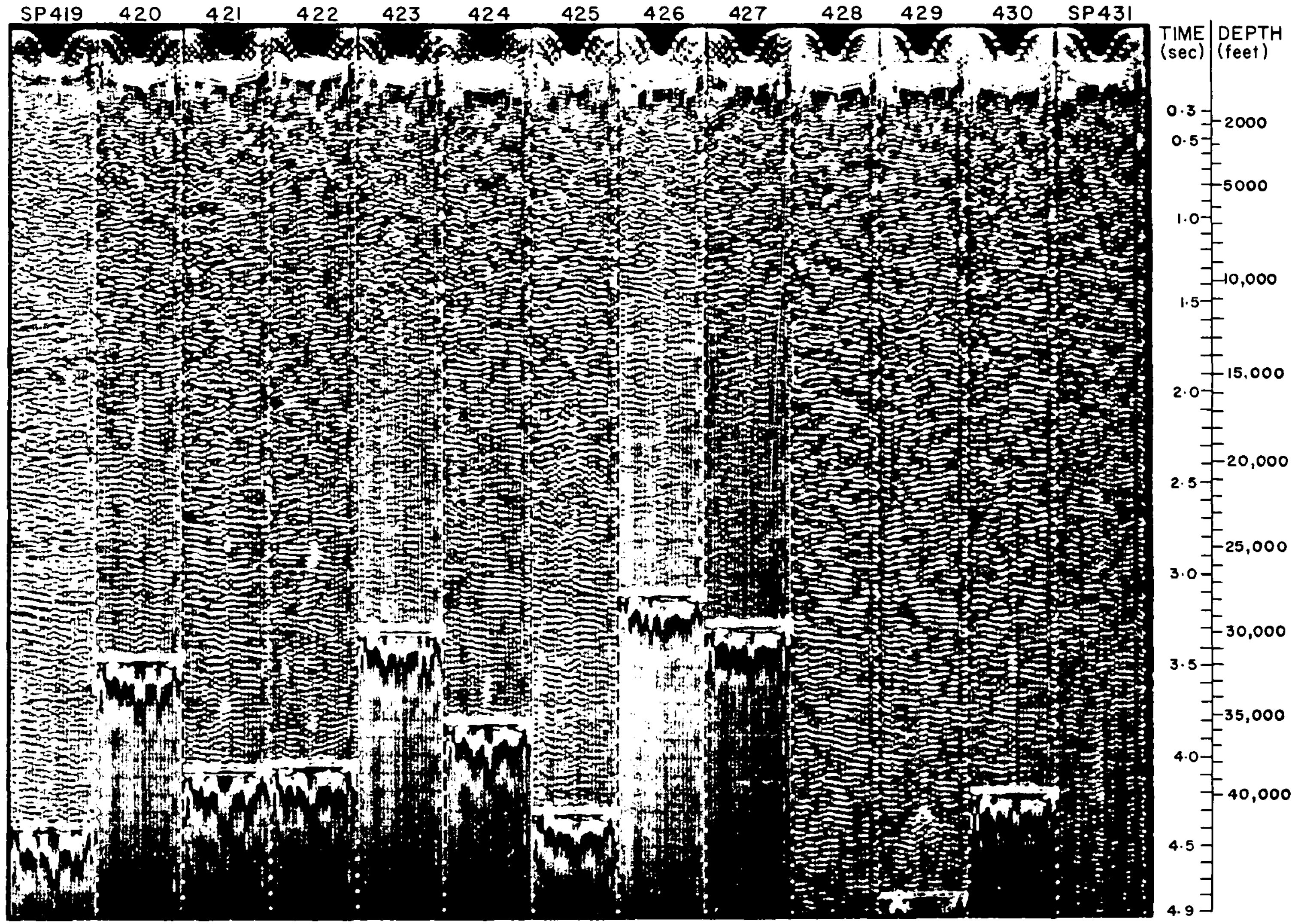
EMERALD DUARINGA SEISM. SURV. QLD., 1960



REFLECTION TRAVERSE J
"MIGRATED" CROSS - SECTION

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F55/B3 -24
To Accompany Record No. 1965/2

PLATE 27



VARIABLE - INTENSITY CROSS - SECTION

TRAVERSE K

HORIZONTAL SCALE IN MILES

0 ¼ ½ 1

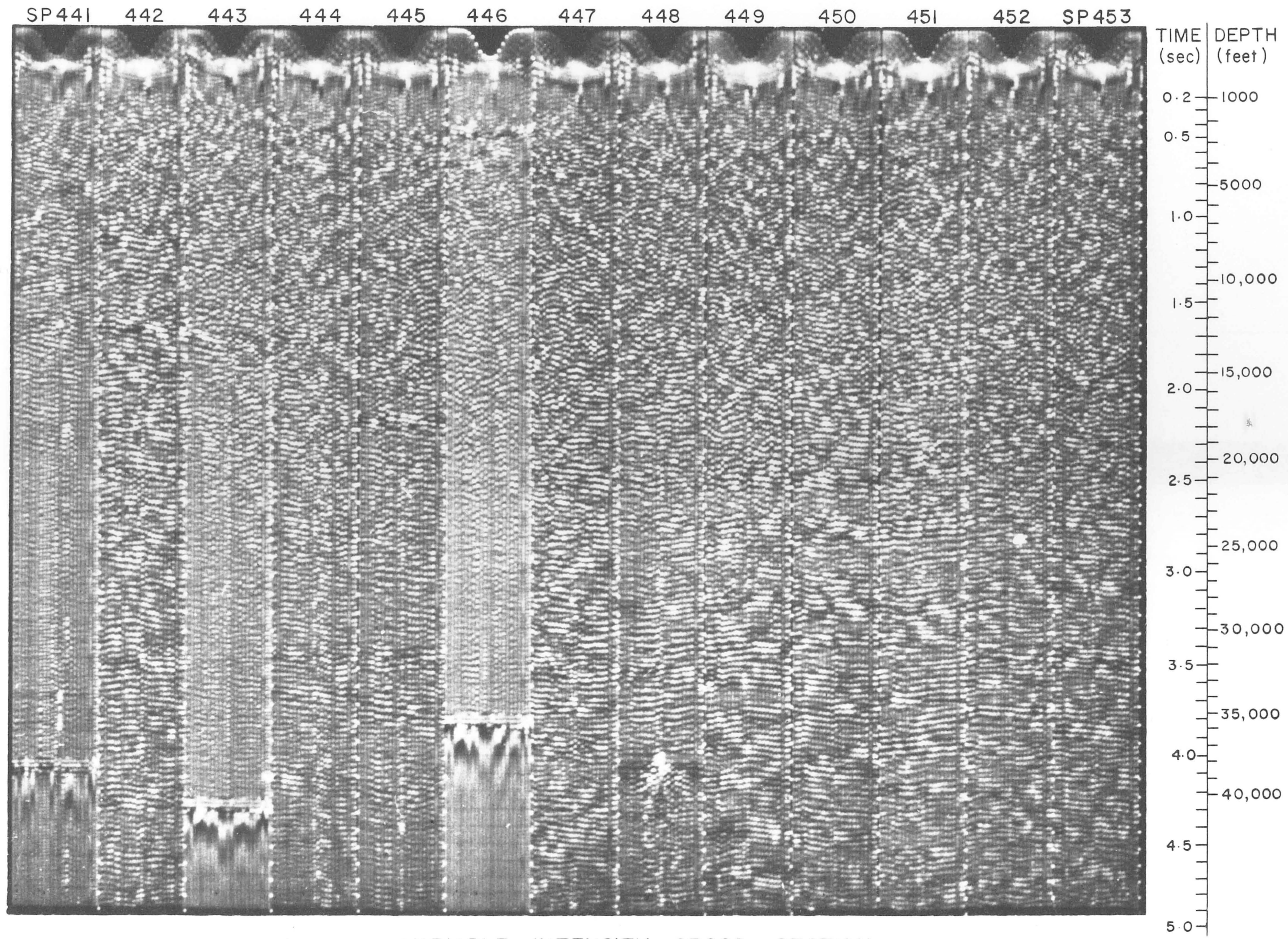
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

To Accompany Record No. 1965/2

F 55/B3-14-1

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics
F55/B3-15-1
To Accompany Record No.1965/2

PLATE 28

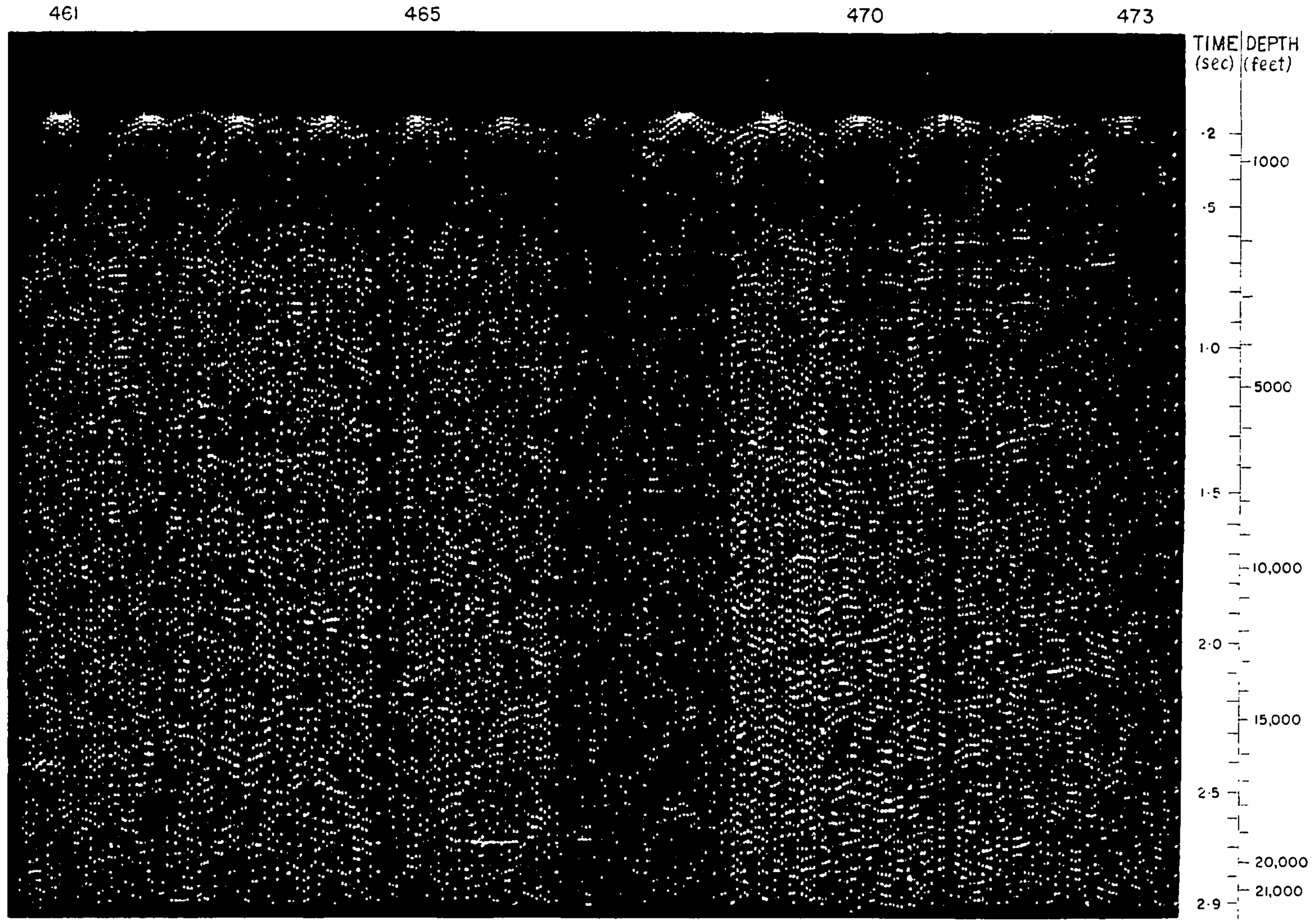


VARIABLE - INTENSITY CROSS - SECTION

TRAVERSE L

HORIZONTAL SCALE IN MILES

0 1/4 1/2 1



BOWEN BASIN

VARIABLE-INTENSITY CROSS-SECTION

TRAVERSE M

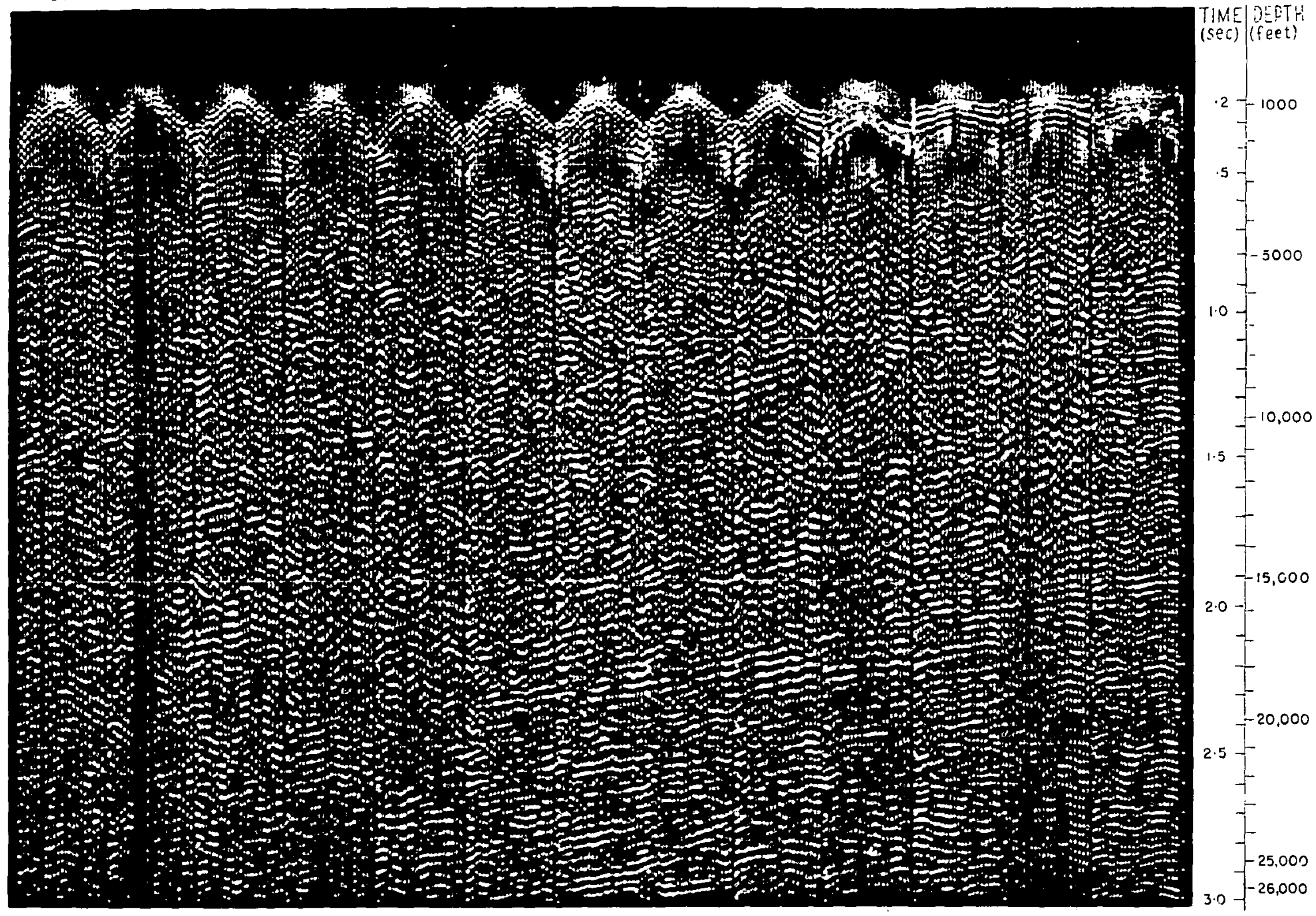
HORIZONTAL SCALE IN MILES

0 1/4 1/2 1

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F55/B3-7-1

To Accompany Record No.1965/2

BOWEN BASIN



VARIABLE - INTENSITY CROSS-SECTION

TRAVERSE N

HORIZONTAL SCALE IN MILES

0 1/4 1/2 1

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F55/B3-8-1

To Accompany Record No.1965/2