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# Flinders River Seismic Survey, Queensland 1966



by

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CONTENTS



ILLUSTRATIONS

## SUMMARY

In the seven months from the beginning of May to the end of November 1966, the Bureau of Mineral Resources carried out a seismic survey on the Flinders Regional Gravity Low in north-central Queensland. The first six months of the survey were spent in investigating the sedimentary section between Richmond and Julia Creek, particularly to determine whether there was any appreciable thickness of Palaeozoic sediments. The seismic results indicated that basement was reasonably shallow and that no appreciable thickness of Palaeozoic sediments can be expected in the area. One month of the survey was then devoted to seismic work near Bowen Downs Homestead, north of Aramac, in an effort to determine the location of the western margin of the Drummond Basin. Although the results were inconclusive in this regard they did demonstrate that the sediments of the Drummond Basin increase in thickness rapidly to the east in the area surveyed.

### Editorial Note

Quantities in this report are expressed in metric units in accordance with BMR policy. During the actual field work and during the original drafting of this report, however, English units were used. It will be clear to the reader that the techniques were appropriate to geophone cables 1800 feet long, and that the traverses were pegged in miles. Also in the conversion to metric units it is inevitable that some figures will appear to have an inappropriate degree of accuracy. The variable-area cross-sections had already been photographed, together with their shooting data expressed in English units, before the change to metric units. It was considered unnecessary to rephotograph these illustrations, and the reader should have no trouble on this account.

## 1. INTRODUCTION

During May to November 1966, the Bureau of Mineral Resources (BMR) carried out a reconnaissance seismic survey in the northern part of the Eromanga Basin in Queensland. In previous years this area had been mapped by BMR's Geological Branch (Vine, Bastian & Casey, 1963; Vine, Casey & Johnson, 1964) and had also been covered by reconnaissance helicopter gravity surveys. On the basis of the correlation between the geology and the Bouguer anomaly map the Eromanga Basin has been divided into a number of gravity provinces (Gibb, 1966b). The purpose of this survey was to investigate one of these provinces - the Flinders Regional Gravity Low - with particular reference to the extent of Palaeozoic sedimentation throughout the area. A subsidiary objective was to provide a tie with previous seismic work.

The terrain of the area traversed ranges from flat to gently rolling. The larger part of the area is given over to sheep grazing with some low-density cattle grazing in open forest areas. Water supplies in the area are obtained mainly from bores as lake and creek beds are normally dry except during extremely wet seasons.

## 2. GEOLOGY

### General

The Great Artesian Basin is composed of three major units: the Surat, Eromanga, and Carpentaria Basins. The area of the survey is towards the northern margin of the Eromanga Basin. The limits of the northern Eromanga Basin are defined on the west by the Cloncurry Fold Belt and on the east by the Drummond Basin. To the north and northeast the margin of the basin is bordered by the crystalline rocks of the Georgetown Precambrian Complex and the Charters Towers Batholith. The Euroka Ridge was postulated as a shallow basement ridge joining the Cloncurry Fold Belt to the Georgetown Precambrian Complex, but doubt has recently been raised on its existence. The Mesozoic sediments thicken and open out in the south while in the northwest the relation of the sequence of rocks to the Carpentaria Basin is unknown.

Metamorphic rocks crop out in the northeast of the RICHMOND 1:250,000 sheet area , within the general area of the survey. The structural trend of the Cloncurry Fold Belt is reflected within the survey area by the NNW strike of the St Elmo Structure in JULIA CREEK.* Faulting and folding of the Mesozoic sediments is slight and appears to reflect the rejuvenation of pre-Jurassic structures. A map of the geology of the area is given in Plate 1.

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* Throughout this report the names of 1:250,000 sheet areas will be written in capital letters to distinguish them from ordinary place names.

## Stratigraphy

The main outcrop of Precambrian rocks in Queensland occurs west of the northern part of the Eromanga Basin (see Plate 1). This outcrop appears as a meridional belt near the Northern Territory border. The area of Precambrian rocks is known as the Cloncurry Fold Belt. Lower Proterozoic metasediments and metamorphic acid and basic lavas, overlain by almost unaltered Middle Proterozoic rocks, make up this belt. Basic and acid igneous intrusions occurred during the orogenic phase before the Palaeozoic sedimentation. Vine and Jauncey (1962) describe a possible horst structure in the Mesozoic sediments, situated just east of Julia Creek, known as the St Elmo Structure, which follows the strike of the Cloncurry Fold Belt.

No sediments older than the Mesozoic have been positively dated in the Richmond and Julia Creek areas. Most bottom hole samples from water bores are variously termed by drillers 'granite', 'metamorphics', 'rock', or 'bed rock'. They probably represent a continuation of the Precambrian rocks of the Cloncurry Fold Belt. Deep stratigraphic boreholes drilled on the southern part of MANUKA penetrated 120 metres of Permo-Triassic rocks (Evans, 1962). At Hughenden the town bore (Hughenden No. 1) penetrated about 45 metres of Permian coal, grey shale, and sandstone (Vine et al., 1964).

The pre-Jurassic sedimentary trough to the east, called the Drummond Basin, is separated from the North Eromanga Basin by a wide meridional belt of sand and soil. The stratigraphic column penetrated in Lake Galilee No. 1, which was drilled in the Drummond Basin (Plate 1), is shown in Table 1.

TABLE 1

Stratigraphic Table - Lake Galilee No. 1

| Age | Lithologic unit | Depth of formation top below surface (metres) |
|---|---|---|
| Cainozoic | Surface clay | 0 |
| Middle Triassic | Moolayember Formation, equivalent | 53 |
| Lower Triassic | ( Clematis Sandstone equivalent | 335 |
| | ( Rewan Formation equivalent | 540 |
| Upper Permian | Un-named | 862 |
| | Unconformity | |
| Lower Permian | Un-named | 1060 |
| Carboniferous? | | 2841 |
| Devonian | Total | 3406 |

## TABLE 2

### Stratigraphic Sequence, Great Artesian Basin

| Age | Western Margin: Unit | Western Margin: Lithology | Western Margin: Thickness | Eastern Margin: Unit | Eastern Margin: Lithology | Eastern Margin: Thickness |
|---|---|---|---|---|---|---|
| LOWER/UPPER CRETACEOUS | Winton Formation | Thickly interbedded arkose & siltstone, non-marine | 3000' + Patchawarra Bore (Winton Formation and Mackunda Beds) | Winton Formation | Shale & sandstone coal seams, lacustrine | 1400' + |
| LOWER CRETACEOUS | Mackunda Beds | Thinly interbedded arkose & siltstone, transitional beds | | | | |
| LOWER CRETACEOUS | Upper Wilgunya Formation | Shale, siltstone, & clay, marine | 3000' + Adria Downs Bore (Upper Wilgunya Formation to Lower Wilgunya Formation) | Tambo Formation | Mudstone, shale, sandstone, & limestone beds | 3200' + (Tambo Formation and Roma Formation) |
| LOWER CRETACEOUS | Toolebuc Member | Calcareous sandstone & calcareous siltstone | | | | |
| LOWER CRETACEOUS | Lower Wilgunya Formation | Shale, siltstone, & clay, marine | | Roma Formation | Mudstone, shale, sandstone, & limestone beds | |
| LOWER CRETACEOUS/ UPPER JURASSIC | Longsight Sandstone | Mainly sandstone & conglomerate, marine & fresh-water deposits | 450' + | Transition Beds | | |
| UPPER JURASSIC | | | | Blythesdale Group (INCLUDING GILBERT RIVER FORMATION) | Shale & sandstone, non-marine | 1200' + |
| MIDDLE JURASSIC | | | | Walloon Coal Measures | Shale, siltstone, sandstone, & coal seams | |

Notes: The above successions are known from boreholes to rest on variable basement rocks ranging in age from Triassic to Precambrian

After R.A.GIBB (1967)

Where the Triassic and Lower Jurassic rocks are exposed they are generally massive, poorly cemented sandstones, largely of freshwater origin, and include coal measures. The poor cementation accounts for the lack of outcrop between the Great Artesian and Drummond Basins.

The Upper Jurassic and Cretaceous rocks are the most common rocks in outcrop in the Great Artesian Basin. Where the basal members of the succession are seen, they appear to lie almost conformably on the Permian rocks. In the east the basal member, called the Gilbert River Formation, can be correlated with part of the Blythesdale Group of the Roma area. The outcrops of this formation consist of interbedded conglomerate, grit, sandstone, and siltstone. The basal member, known in the Julia Creek area from boreholes as the Longsight Sandstone, is transitional from freshwater to marine sedimentation. The subsequent marine sequence of the Wilgunya Formation is split by a distinct lithological member known as the Toolebuc Member. This member is indicative of clear seas and contains abundant fossils of Aptian (Lower Cretaceous) age. The uppermost beds of the Wilgunya Formation indicate a shallow marine environment with a steady decrease in fauna as the sea became a brackish inland sea (Vine et al., 1963).

The Upper Cretaceous (Cenomanian or later) follows conformably with the Winton Formation. The lithology indicates filling of a very shallow sea by a major system of deltas extending westwards into the Eromanga Basin.

Thin Tertiary sedimentary deposits overlie the Cretaceous with unconformity in places, often visible as a capping or a low hill. Tertiary basalt flows enter the region from the east and cover much of the northeast of RICHMOND; they are thickest in old river valleys.

Much of the area is covered by a thin veneer of Quaternary sand, gibbers, and alluvium.

Table 2 is a stratigraphic sequence for the Great Artesian Basin, reproduced from a report by Gibb (1967).

## Tectonics

There are no major tectonic events affecting the Upper Jurassic and Cretaceous of the North Eromanga Basin. The nature of pre-Jurassic tectonic movements can only be inferred from the outcrops on the margins of the basin. The subsurface structure of the Mesozoic sediments in the Eromanga Basin, as deduced from a study of water bore logs, indicates that the main trend of faulting or folding is NNE; this trend is considered to reflect the structure in the basement. All folding appears to be gentle and due to settling of the basin sediments.

The outburst of Tertiary vulcanism in the east appears to have had no structural effect on the basin sediments.

## 3. PREVIOUS GEOPHYSICS

### Gravity surveys

Ground gravity surveys were carried out in Central Queensland by the Bureau of Mineral Resources between 1958 and 1963. In this period a number of regional traverses were surveyed and tied to pendulum stations. Helicopter gravity surveys were done in the area in 1959 (Gibb, 1967), 1961 (Lonsdale, 1962; Gibb, 1968), 1963 (Gibb, 1968), and 1966 (J.E. Shirley, in prep.). Other gravity surveys conducted in the area were done by BMR officers, who took gravity readings along Exoil seismic lines (Darby, in prep.) and by Magellan Petroleum Corp. (1961), which carried out the North Winton gravity survey. The results of these surveys have been compiled into a composite Bouguer anomaly map (Gibb, 1968).

On the basis of the correlation of the geology and the Bouguer anomalies the area has been divided up into four main provinces: the Cloncurry Regional Gravity High, the Anakie Regional Gravity High, the Muttaburra Gravity Ridge, and the Flinders Regional Gravity Low (see Plate 4).

The Flinders Regional Gravity Low covers the northern and northeastern part of the Eromanga Basin. It can be seen from the Bouguer anomaly map that the regional trend of the zone is northwest but that some gravity sub-units have northeast trends. The area lies to the north of the Muttaburra Gravity Ridge and is bounded to the west and east by the Cloncurry and Anakie Regional Gravity Highs respectively. The area to the north was surveyed during 1966. (Shirley, in prep. 1967).

The Flinders Regional Gravity Low has been divided into three gravity units (Plate 5): the Nonda Gravity Depression, the Richmond Gravity Shelf, and the Tangorin Gravity Depression.

The Nonda Gravity Depression is a belt of negative Bouguer anomalies in which the main trend is NNW, with minor northeast trends. There is no direct correlation between the gravity unit and the exposed geology of the area. The anomaly may be due to a thickening of Mesozoic sediments eastwards from the Cloncurry Gravity High in conjunction with the presence of older, lighter sediments; alternatively, it could be due to a change in basement density.

The Richmond Gravity Shelf is a zone characterised by small, local gravity highs and lows. These rapid variations in Bouguer anomaly may correlate with density contrasts in a shallow basement which might exist in this area.

The Tangorin Gravity Depression is an extensive NW-trending gravity low centred on TANGORIN. In general the gravity gradients in this gravity unit are less steep than elsewhere in the Flinders Regional Gravity Low, and it was thought that these might reflect a thick sedimentary section.

The term "Cloncurry Regional Gravity High" is used to describe the regional gravity high that extends over the Cloncurry Fold Belt and its buried extensions. The Cloncurry Regional Gravity High has also been divided up into a number of gravity units, of which the Julia Creek Gravity Shelf is of importance to this report. The Julia Creek Gravity Shelf suggests a shallow eastern extension of the Precambrian of the Cloncurry Fold Belt below the Mesozoic sediments which crop out in this area.

An extensive gravity gradient trending NNW across the east of McKINLAY and JULIA CREEK separates the Julia Creek Gravity Shelf from the Nonda Gravity Depression. The strongly negative Bouguer anomalies of the Nonda Gravity Depression suggest the possible presence of excess light material in the geological section. This conclusion is in agreement with Vine and Jauncey (1962), Whitehouse (1955), and Ogilvie (1955) who have all suggested possible deepening basement and thickening sedimentary section eastwards from the Julia Creek Gravity Shelf on the basis of geological evidence. East of the St Elmo Structure no water bores penetrate the base of the Lower Cretaceous Longsight Sandstone, and it appears certain that the Mesozoic section thickens eastwards. The possibility of older sediments in the Nonda Gravity Depression cannot be excluded. Thus the gravity gradient suggests a marked deepening of the basement just east of the St Elmo Structure, and that the Euroka Ridge of Hill (1951) does not exist in this area.

Outcrops of Precambrian metamorphics, which include metasediments, metamorphosed granites, and metamorphosed basic igneous rocks, occur as inliers in valley bottoms in northeast RICHMOND and north HUGHENDEN. The main lithological trends are northeast, as are many of the gravity trends in this zone. This supports an interpretation of the gravity in terms of shallow basement structure.

The NW-trending Tangorin Gravity Depression extends from central RICHMOND to central GALILEE and occupies almost all of TANGORIN. Mesozoic sediments crop out over the whole gravity depression and afford few indications of the possible structure at depth.

Seismic work carried out in the area by the Artesian Basin Oil Company and Exoil N.L. indicated the presence of about 1500 metres of Mesozoic sediments in places, and a maximum sedimentary thickness of about 5200 metres. This tended to suggest that the gravity unit was directly related to the presence of thick, light sediments.

Aeromagnetic surveys

An aeromagnetic survey was conducted over the area covered by this report during 1966. The results of this survey are not yet available. In 1958 the Bureau of Mineral Resources carried out an aeromagnetic reconnaissance survey (Jewell, 1960) consisting of a series of widely spaced traverses in the western part of the Great Artesian Basin, one traverse of which crossed the area of interest to this report. Exoil N.L. (1962a) made a survey of the Aramac-Mount Coolon area, covering the eastern part of the Tangorin Gravity Depression and the Drummond Basin. A survey of the Winton-Muttaburra area was made in 1956 by the Central Queensland Petroleum Pty Ltd and Catawba Corporation, covering part of the Muttaburra Gravity Ridge. Thus the aeromagnetic work completed to date lies only on the margins of the area of this survey.

A comparison of the aeromagnetic results with the main gravity anomalies shows a good qualitative agreement between the two. Areas in which the basement is interpreted as fairly shallow from gravity results, and where the local gravity anomalies are explained by intrabasement density contrasts, correspond to zones of small, intense aeromagnetic anomalies often characterised by steep gradients. In contrast to this the broad, smooth aeromagnetic anomalies with more gentle gradients correspond to areas thought to contain thicker sediments.

The results of the survey by Exoil N.L. (1962a) showed (Plate 6) that the area could be divided qualitatively into three regions of different magnetic character. These are:

(1) A large zone of broad, smooth magnetic anomaly occupying most of BUCHANAN and central GALILEE.

(2) A southwestern zone of smaller, irregular magnetic anomalies in west GALILEE and MUTTABURRA.

(3) An eastern zone of fairly smooth magnetic anomalies in northeast BUCHANAN and east GALILEE.

Exoil's interpretation may be summarised as follows. In the BUCHANAN and GALILEE areas, depths to magnetic basement have been computed and range from 2700 to 4900 metres. These estimates were not considered to be very reliable, but they are the best results obtainable from the survey. In the area of the Great Artesian Basin to the southwest, the depths to magnetic basement range from 1800 to 3700 metres. Magnetic relief is generally related to intrabasement susceptibility changes in this area, and magnetic basement appears to correlate with geological basement, which is considered to be crystalline basement of Lower Palaeozoic or Precambrian age. The most striking feature of the interpretation is a large NW-trending trough about 5200 metres deep centred in north GALILEE and flanked to the northeast and southwest by areas of shallower magnetic basement, which are possibly upfaulted areas. This trough becomes shallower to the southeast towards the Anakie Structural High, and to the northwest it terminates abruptly in north BUCHANAN, where basement is at a depth of 2700 metres.

If correlation between sedimentary thickness and the Bouguer anomalies is normal in this area, as it appears to be, then the above interpretation of the aeromagnetic results does not agree particularly well with the gravity interpretation. The gravity results indicate that the sedimentary trough has its NW-trending axis displaced some 65 kilometres southwest of the deepest magnetic basement depression. However, the gravity trough can be broadly correlated with an area of predominantly smooth magnetic anomalies which occupies most of BUCHANAN and central GALILEE. The more irregular magnetic pattern in southwest GALILEE and MUTTABURRA can be correlated with the Muttaburra

Gravity Ridge, which is interpreted from the gravity and drilling results as being due to a basement swell. The eastern zone of magnetic anomalies in northeast BUCHANAN and east GALILEE corresponds to an area of relatively positive Bouguer anomalies, which become more positive to the east and suggest a basement rise in this direction.

## Seismic surveys

The Artesian Basin Oil Company (1962) conducted seismic work in 1959 in the MUTTABURRA and TANGORIN areas. In 1962-63 Exoil conducted surveys in the Torrens Creek and Lake Galilee-Lake Buchanan areas (Exoil 1962b, 1963b). Amerada Petroleum Corporation of Australia Ltd began a series of surveys in 1965 to link up the Muttaburra, Torrens Creek, and Lake Galilee-Lake Buchanan surveys and to provide a tie between Brookwood No. 1 well and Galilee No. 1 well. These surveys were continued during 1966 and 1967. All of this seismic exploration is at the eastern end of the Flinders Regional Gravity Low and therefore is not directly related to the present survey (Plate 1).

The Muttaburra survey consisted of a number of reconnaissance lines shot using 1609-metre or 3219-metre 'jump' correlation shots. More detailed work was carried out on one structure found north of Muttaburra on what was termed the Muttaburra Prospect. A single hole was used at each shot-point, with four geophones per trace and a 402-0-402 metre split spread. Record quality was fair to good where the shots were fired in blue clay.

A strong, persistent reflector was used as the main basis of correlation. This reflection was believed to represent the "P" reflecting horizon which is widely recorded in other parts of the Great Artesian Basin and which is generally believed to be associated with an unconformity at the base of the Mesozoic or a horizon within the Upper Permian. It indicated that dips were gentle and that the regional dip was to the west. A second horizon, tentatively correlated with the Blythesdale Group*, was also continuous over the Muttaburra Prospect.

In the Muttaburra Prospect a long northerly plunging anticline was shown on the "P" horizon, with its axis bearing almost north-south. On the eastern limb of the anticline there is a narrow synclinal feature. This syncline appeared much wider and shallower on the Blythesdale horizon and several possible closures were shown on the anticlinal axis. In general the thickness of the Mesozoic, as indicated by the gently undulating "P" horizon, is about 1100 metres. In the eastern part of the area reflections were recorded down to 1.2 seconds, indicating a total sedimentary section of about 1500 metres. Brookwood No. 1 well which was drilled on the anticline entered basement at about 1460 metres after passing through some 900 metres of Mesozoic sediments and 550 metres of Palaeozoic

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* The term "Blythesdale" is no longer used as a stratigraphic name. In the Muttaburra area the name "Hooray Sandstone" is recommended.

sediments. A velocity survey carried out in this well (Exoil, 1962a) indicated that the "P" horizon is associated with coal at the top of the Permian.

The Artesian Basin Oil Company authors believe that the Muttaburra area straddles the junction of theLongreach basement ridge and a buried Permian trough to the east. They suggest that this junction may be faulted, and predict that Devonian-Carboniferous rocks of the Drummond Basin probably underlie the Permian sequence. The section penetrated in Lake Galilee No. 1 well (Exoil, 1965) suggests that the latter prediction may be valid.

The Exoil seismic survey in the Lake Galilee-Lake Buchanan area was a combined reflection-refraction survey. Reflection quality varied from good to unreliable, events below "P" horizon (called horizon "A" in the Exoil report) generally being poor.

A reversed refraction profile 20 kilometres in length was shot in the Lake Galilee area. The refraction profile indicated six and possibly seven refractor beds. Velocities and layer thicknesses interpreted by Austral Geoprospectors for Exoil are as follows:

| | | | |
|---|---|---|---|
| $V_1$ = 900 | metres/sec | $d_1$ = 12 | metres |
| $V_2$ = 2110 | " | $d_2$ = 78 | " |
| $V_3$ = 2995 | " | $d_3$ = 126 | " |
| $V_4$ = 3525 | " | $d_4$ = 1040 | " |
| $V_5$ = 4334 | " | $d_5$ = 940 | " |
| $V_6$ = 5384 | " | $d_6$ = 2940 | " (questionable) |
| $V_7$ = 6650 | " (questionable) | | |

Although the refraction profile was inconclusive in the determination of basement depth, several observations could be made from it. At least 2200 metres of sediments overlie the refractor with a velocity of 5384 metres/sec. The company report suggests that reasonably good and continuous reflection events indicate a geologic section of considerably more than 2200 metres. Assuming that the 6650-metres/sec refractor represented basement, then a sedimentary section approximately 5200 metres thick is indicated.

Data obtained from the refraction profile, together with some information gathered from a brief $t:\Delta t$ analysis on the reflection traverses, was used to construct a time/depth and average velocity chart.

In the reflection work three horizons designated horizons "A", "B", and "C" were selected for mapping over the entire area. Recordings were taken using from one to three holes per shot-point and 12 to 16 geophones per trace. It was found that in general good quality records were obtained when shooting in lake beds and dry stream channels but poor results were obtained elsewhere.

Horizon "A" was an outstanding shallow event over most of the area, and it was the most reliable horizon mapped. In general it was continuous, but in many places abrupt character changes occurred. The reflection occurred at a record time of about 0.3 seconds in the east and about 0.8 seconds in the west of the area. One important structure was mapped north of Lake Galilee. A north-trending anticline was revealed, flanked on both the east and the west by north- to NW-trending synclines. Good dip evidence observed in all four directions indicated a closed anticlinal feature with at least 30 milliseconds' closure.

According to Austral Geoprospectors' report for Exoil, horizon "B" originates from very near an unconformity. Although the reflection may be complicated by multiples it is considered to be a true structural marker. Reflection phasing, minor faulting, and abrupt discontinuities are numerous on this horizon. In general horizon "B" shows the same features as horizon "A". However, on the structure north of Lake Galilee, more east dip is present and the highest structural point is shifted to the northeast. Horizon "B" occurred at a reflection time between 1.0 seconds in the east and 1.6 seconds in the west.

The overall quality of reflection horizon "C" is low. It is believed that the event may be complicated by multiples arising from the strong reflection horizon "A" which interrupt the continuity of the event. It is postulated in the company report that horizon "C" originates from near a major unconformity. In the southern part of the area a northwest-trending anticline with a gentle northwest plunge was mapped. The structure generally follows that shown by horizons "A" and "B". Thinning of section between horizons "A" and "B" is evident over the structure, indicating the presence of an old uplift. Considerable faulting is postulated to be associated with the structure at this depth, and the feature was mapped as a horst block. However, dip in all directions is present exclusive of faulting. Horizon "C" is not conformable with horizons "A" and "B" and exhibits a greater structural relief. Whereas horizons "A" & "B" show regional dip to the west, horizon "C" dips regionally to the northeast. The presence of a deep basin or trough trending northwest and plunging to the northwest is indicated by this horizon. Reflections were recorded at 1.8 seconds in the southwest and down to 2.7 seconds in the northeast.

Lake Galilee No. 1 well, which was drilled on the structure north of Lake Galilee, indicated that horizon "A" originated from the top of the Permian, horizon "B" from within the Permo-Carboniferous sequence, and horizon "C" from the Drummond sequence.

Results obtained by Exoil from the Torrens Creek area (1963b) were similar to those obtained in the Lake Galilee-Lake Buchanan area. Two reflecting horizons, designated "A" and "B", were selected for mapping over the whole area. Good quality reflections were obtained from horizon "A" over most of the area. Numerous character changes and 'pinching out' of first-cycle energy occur. It is likely that horizon "A" corresponds with the "P" horizon mapped in many parts of the Eromanga Basin. The contour interpretation derived from reflection data on horizon "A" suggests a series of northwest-trending folds which are more or less parallel. Regional dip was to the northwest with reflection time between 0.75 and 0.85 seconds.

Continuous correlation on horizons below horizon "A" was not possible because the reflections showed poor continuity and a lack of diagnostic character. Multiples were probably present. However, as many events as possible were picked and plotted and a phantom horizon (horizon "B") was constructed from them where necessary. Horizon "B" was found to be reasonably consistent. Approximately 70 percent of the data presented in the report for this horizon were based on continuous correlation and about 30 percent were based on a phantom horizon. A similar anticlinal trend to that found on horizon "A" was found on horizon "B". Breaks in reflection continuity and shifts of the maximum reflection amplitude from one cycle to another suggest the presence of minor faulting, horizontal facies changes, or other changes in the reflecting zone. The alignment of these reflection character changes appears to be parallel to the major trend. Horizon "B" occurred at a reflection time between 1.55 and 1.8 seconds.

There is some indication of thinning of section over the anticlinal folds and thickening in the synclines.

One 20-kilometre reversed refraction profile was also shot in the area. Six refractors were recorded with velocities ranging from 900 to 6020 metres/sec. The refraction results were used to compute time/depth and average velocity curves. These curves were used to convert the reflection times to depths below sea level, and the reflection events were superimposed on the refraction cross-section. This indicated that neither horizon "A" nor horizon "B" had a refraction counterpart. Taking the 6020-metres/sec refractor to represent basement, a thickness of about 3700 metres of section was indicated.

From September 1965 to September 1967, Amerada Petroleum Corporation made a survey in the Hughenden-Muttaburra-Bowen Downs area designed to link up all previous seismic surveys in the region and to provide a tie between Brookwood No. 1 and Lake Galilee No. 1 wells. The work was carried out by a Namco Geophysical Company seismic crew and a Petty Geophysical Engineering Company seismic crew using explosives, and finally by a Ray Geophysics (Australia) "thumper" crew.

The area was initially traversed using shot-hole reflection techniques, either continuous profiling or spot correlation with shot-points every 1200 metres. One 40-kilometre line (P 13) was shot using common depth point (CDP) recording with 12-fold stacking. Shot-hole patterns contained between one and nine holes, and recording was done with eight to sixteen geophones per trace.

Record quality was in general fair to good but was found to be dependent on surface conditions; laterite on the surface and in shot-holes caused a deterioration. Horizon "A" or "P", a strong persistent event believed to originate near the top of the Permian, was recorded throughout the area with fair to good quality, but events occurring below horizon "A" were generally poor or non-existent. The CDP line was shot in an effort to improve the quality of the deeper events.

The results have been presented by Amerada as time contour maps drawn on horizon "A" (Amerada, 1967). Relief is gently undulating with regional dip to the west and north; horizon "A" occurs at a record time of 0.4 to 0.5 seconds in the east of the area and at around 0.8 seconds in the west. Sporadic events down to 2 seconds two-way time show similar dip directions.

Two major structural trends are evident from the contour maps: a pronounced northeast trend in the south of the area and a lesser-developed northwest trend in the north. Five anticlinal anomalies have been identified, three in the south and two in the north. One anomaly was traversed by the CDP work of Line P 13. Structure is interpreted as being due to drape over older highs, with faulting rare at horizon "A" level. The objective of investigating the extent and attitude of the pre-Permian sedimentary section was, for the most part, not accomplished, owing to lack of good-quality deep data.

The "thumper" crew was brought in to try to improve the quality of the pre-Permian reflection data; to some extent they achieved this objective, as the pre-Permian events were more continuous than those previously obtained. The "thumper" seismic work was mostly six-fold CDP.

A "thumper" line run between the Thunderbolt and Lake Galilee wells clearly shows the unconformity between the Palaeozoic sediments of the Drummond Basin and the Permian section, and that the margin of the Drummond Basin lies between these two wells, probably in the vicinity of longitude 145°30'. A large extent of Permian sedimentation can be inferred from the seismic work in general and to some extent this correlates with the eastern part of the Flinders Regional Gravity Low.

Thunderbolt No. 1 well was drilled on the anticlinal anomaly on Line P 13 in 1967. This well entered volcanic basement at about 1608 metres after penetrating 880 metres of Mesozoic sediments and 730 metres of Upper Permian and possibly older Palaeozoic sediments. A velocity survey conducted in Thunderbolt No. 1 indicated that the average velocity to basement was about 3109 metres/sec (J. Gilliam, Amerada, pers. comm.).

The average velocity down to horizon "A" ranges from approximately 2680 metres/sec at Brookwood No. 1 to about 3230 metres/sec at Lake Galilee No. 1. An $X^2$-$T^2$ plot obtained from an expanded spread indicates an average velocity to horizon "A" at 0.75 seconds of 2900 metres/sec, and an average velocity of 3109 metres/sec to a record time of 1.3 seconds. Velocity information obtained from a $t:\Delta t$ analysis of reflections indicates average velocities varying between 2400 and 3000 metres/sec down to a reflection time of 1.5 seconds. Further velocity information in the area was obtained from a velocity shoot carried out in Brookwood No. 1 well (Exoil, 1963a) and from a sonic log run in Lake Galilee No. 1 well (Exoil, 1965).

## 4. OBJECTIVES OF SURVEY AND PROGRAMME

Proposed programme

The general objective of the survey was to carry out a seismic reconnaissance on the Flinders Regional Gravity Low, with particular reference to the extent of Palaeozoic sedimentation. Several seismic surveys had already been carried out on the southeastern half of the Flinders Regional Gravity Low, in the Tangorin Gravity Depression; and Amerada Petroleum Corporation continued an extensive seismic survey in this area during 1966, so that BMR's 1966 survey was confined mainly to the northwestern portion of the Flinders Regional Gravity Low, i.e. in the northwestern part of the Tangorin Gravity Depression and in the Nonda Gravity Depression. As the emphasis was on investigating the Palaeozoic sequence below the Mesozoic, an attempt was made to develop a shooting method that would record reliable reflections from below horizon "A". Previous surveys had found this difficult. The objectives of the survey were more specifically stated as follows:

(1) To develop a technique that would record reliable reflections from the Palaeozoic sequence where it might exist in the Flinders Regional Gravity Low.

(2) Where the opportunity existed, to confirm that the "A" reflection is associated with the top of the Permian.

(3) To investigate the northwest end of the Tangorin Gravity Depression for extent of Palaeozoic sediments, and to tie the seismic results to outcrop in the north and to bores in the south.

(4) (i) To determine whether the Nonda Gravity Depression results from a thickening of sediments, including Palaeozoic sediments, east of the St Elmo Structure or from a change in basement density.

(ii) To investigate the St Elmo Structure.

(5) To investigate whether the supposed Euroka Ridge exists as a continuous barrier between the Eromanga and Carpentaria Basins north of Julia Creek.

(6) To integrate BMR's 1966 work with the previous seismic surveys to the southeast including the work carried out by Amerada Petroleum.

(7) If a technique for recording reflections from the Palaeozoic was developed which was notably more successful than those applied previously, then to test this technique in the southeast end of the Tangorin Gravity Depression.

(8) If time permitted, to investigate the southern end of the Nonda Gravity Depression.

The programme was planned as follows:

(a) Shoot a reflection traverse from Rowen Lynn No. 2 bore, where basement was encountered at 910 metres, to Moselle (see Plate 2). A certain amount of experimentation would be carried out to determine a suitable technique.

(b) (i) Continue the reflection traverse northwards through Coalbrook, where coal has been recorded at less than 90 metres (Bush Pelican Bore) to determine whether coal is associated with the "A" reflection recorded in the area. This traverse would also be tied to metamorphic basement north of Coalbrook if possible.

(ii) Experimental work to be carried out to evolve a technique for obtaining reflections below horizon "A" if there was evidence that an appreciable sedimentary section exists below horizon "A" in this area. If not, this work would be carried out elsewhere in a suitable area.

(iii) A refraction probe to record all refractors to basement to be shot on (a) or (b) where the sedimentary section approaches maximum thickness.

(iv) Attempt to obtain a core from the coal to enable a spore examination to be carried out by the Geological Branch of BMR.

(c) Shoot a reconnaissance reflection traverse from Julia Creek across the St Elmo Structure and the Nonda Gravity Depression onto the Richmond Gravity Shelf.

(d) Shoot a reconnaissance reflection traverse on the gravity low in north central JULIA CREEK. A refraction probe would be shot on this traverse or (c) to measure basement velocity and to assist in determining the depth to igneous or metamorphic basement.

(e) Shoot a reconnaissance reflection and/or refraction traverse on the postulated Euroka Ridge between Millungera Homestead and Savannah Downs Homestead to obtain evidence for or against the existence of the supposed ridge in this area.

(f) Provide a tie between BMR's 1966 work and the Amerada work. Details of this tie would be decided after the completion of the Amerada work.

Actual programme carried out

The operational statistics of the survey party are summarised in Appendix B.

In order to carry out programme item (a) (see last section), Traverse A (see Plate 2) was surveyed north from Rowen Lynn No. 2 bore towards Moselle, using 549-metre shot-point intervals. Noise tests were carried out at SP100 and SP135 to determine the optimum spacings for geophone groups and shot patterns. A velocity spread was shot between SP110 and SP118 to provide supplementary velocity information for incorporation in a $t:\Delta t$ analysis carried out in the traverse.

Traverse A was extended west to Richmond and then north towards Coalbrook in order to fulfil programme item (b). As reflection quality north of Richmond was very poor, reflection profiling was terminated well south of Coalbrook. It was therefore not possible to determine whether horizon "A" is associated with the coal recorded in Bush Pelican Bore. An attempt was made to record events below horizon "A" using the refraction method. The refractor followed in this work has been interpreted as representing basement, and the results indicated that there is no appreciable thickness of Palaeozoic section in the area. Refraction velocity measurements were made to the north on Traverse C (Plate 2) near outcrops of the basement, to confirm this hypothesis. In an effort to determine whether there is a thick sedimentary section below horizon "A", a small amount of experimental work was done between SP153 and SP157; no events were recorded below horizon "A". Part (iv) of programme item (b) was not carried out, as a suitable core barrel was not available.

Programme item (c) was accomplished by the shooting of Traverses D and E (Plate 2). Traverse D was not shot continuously as no evidence of the existence of a thick Palaeozoic section was obtained. Both the refraction and reflection methods as well as offset reflection/refraction shooting, were employed on this traverse. The offset shooting technique used is described in the next chapter. It was here aimed at determining the relation between basement and the reflections recorded.

Continuous refraction profiling was used to delineate the St Elmo Structure. Reflection profiling across the structure proved unsatisfactory as the main reflection was so shallow that it suffered considerable interference from the first breaks.

In order to get a three-dimensional picture of some deep events occurring at the western end of Traverse D, Traverse E was surveyed at right angles through SP1105. This traverse was shot continuously using reflection profiling.

Traverse F was surveyed 50 kilometres north of Nelia near Woodlands Homestead (see Plate 2) in order to carry out programme item (d). The traverse was shot using both reflection and offset reflection/refraction methods. As the reflection results indicated that basement was fairly shallow, no refraction work was carried out.

It was not considered worthwhile to carry out programme item (e). This item presupposed that there was relatively deep basement in the Nonda Gravity Depression south of the "Euroka Ridge". In fact results obtained from Traverses D and F indicated that basement was fairly shallow and was rising to the north.

Amerada Petroleum Corporation completed seismic work so close to Traverse A that it was not considered necessary to tie between the two surveys as had been proposed in programme item (f).

As time was available, it was decided to survey Traverse G (Plate 2) to investigate the southern end of the Nonda Gravity Depression (Objective item 8). This traverse was shot using both reflection and offset reflection/refraction methods. In addition, three short refraction probes (Traverses X1, X2, X3) were made, to investigate the Toolebuc Member of the Wilgunya Formation in order to study the problem of attenuation of energy in thin refractors. The Toolebuc Member was recorded clearly on gamma-ray logs run by BMR in the area, so its depth and thickness were accurately known. The traverses were shot in order to determine whether the Toolebuc Member would provide a good model to use for experimental work on thin refractors.

In the time allotted for programme item (f) it was decided to carry out some refraction work in the Bowen Downs area, north of Aramac, aimed at determining the western limit of the Drummond Basin between Lake Galilee No. 1 and Brookwood No. 1 wells. This area had been covered by Amerada Petroleum Corporation using reflection methods but the results were inconclusive regarding the existence of pre-Permian sediments. Initially a refraction probe to record all refractors to basement was shot on Amerada's Traverse P13 (Plate 3) using shot-to-geophone distances from 0 to 19 kilometres. The probe did not record any obviously Palaeozoic refractors but a refractor probably representing basement occurred about 600 metres below horizon "A". Another refraction probe was then shot on Traverse P10 (Plate 3), again using shot-to-geophone distances from 0 to 19 kilometres. One refractor was recorded between horizon "A" and supposed basement, and had a velocity probably representative of Palaeozoic rocks.

During the course of the season a total of 9½ working days was lost because of rain. The greater part of this time was lost in the Bowen Downs area, where one working week was lost when heavy rain caused all the creeks in the area to flow.

## 5. TECHNIQUES

### General

All shots throughout the survey were recorded both on magnetic tape on a PMR-20 FM recorder and on paper record using an S.I.E. TR06 oscillograph. The seismic amplifiers were Texas Instruments 7000B. All the equipment used is summarised in Appendix A.

All traverses on the survey, with the exception of the shallow refraction Traverses X1, X2 and X3, were shot using a 549-metre shot-point interval.

### Reflection traverses

Before reflection shooting was commenced on Traverse A (Plate 2), a series of noise tests was carried out at SP100 to determine a suitable shot-hole/geophone arrangement. A further series of noise tests was carried out at SP135 in order to review the recording technique being used.

The results of the noise test shot at SP135 are shown in variable area record form in Plate 30. A plot of frequency against wave number for all pickable events recorded at this shot-point is shown in Plate 31. As can be seen from Plate 30, the greater part of the shot-generated noise was of the coherent or organised type. The transverse or cross spread record on the plate indicates that no noise travelling at right angles to the traverse was generated. The noise test results indicated that linear shot and geophone patterns would be most effective in attenuating the greater part of the noise.

Traverse A was shot initially using 5-hole shot patterns, the holes being in line with the traverse, 9.8 metres apart and 37 metres deep. Sixteen geophones were used per trace, the interval between geophones being 3 metres. This shot-hole/geophone arrangement was used between SP100 and SP206 almost exclusively. In some parts, however, the number of geophones was increased to thirty-two, in two rows of sixteen, 9 metres apart, in an effort to improve results.

If the wave number cut-off point for the spatial filter constituted by a linear array of shot-holes or geophones is defined as

$$k_c = 1/ne \quad \text{(Smith, 1956)},$$

then the cut-off wave number for the shot-hole and geophone patterns mainly used on Traverse A is $k_c$ = 0.01024 cycles per metre. It can be seen from the graph for SP135 in Plate 31 that spatial filters with such a cut-off point should be effective in attenuating the coherent noise recorded, which is plotted to the right of this wave number, in the region of attenuation.

Some experimental shooting was conducted between SP153 and SP157 under the direction of Mr E.H. Schwing of the French Petroleum Institute (I.F.P.). In this region some poor evidence of deep events at about 2.2 seconds had been obtained, and this experimental work was designed to enhance these events. In a series of tests, the geophone interval was successively increased from 3 to 4.5 metres and then to 6 metres; the number of geophones was increased from 16 to 24; the number of holes was increased from five to seven; and the shot-hole spacing increased from 9.7 to 15.2 metres. All these modifications decreased the wave-number cut-off, $k_c$, and improved record quality. Two parallel lines of geophones each containing 16 and then 24, and also two parallel lines of holes each containing seven holes were tried. A reduction in transverse random noise was obtained, with some improvement in reflection quality. Charge comparison tests of 4.5, 9, 11, and 13 kg of "Geophex" per hole, all at a depth of 37 metres, showed that a 9-kg charge was an improvement over 4.5 kg, but still larger charges gave no further improvement.

Shot-points 204-206, Traverse A, were then reshot and the traverse was continued to SP227 using the technique of seven holes in line with the traverse and 20 metres apart and 24 geophones per trace in line, parallel to the traverse, with an interval of 6 metres. The hole depth was 37 metres and charge per hole 11 kg. This particular spacing was used because a number of holes had already been drilled and this arrangement could utilise some of them. Slightly improved results were obtained from SP204 to 206 but there was no evidence of definite reflection events below horizon "A" over the whole section.

Traverse A between SP134 and SP140 was then reshot using the increased effort technique, namely seven holes in line with the traverse at a spacing of 15 metres, and 32 geophones per trace in two parallel lines along the traverse, 9 metres apart, with a geophone interval of 6 metres. There was a marked improvement in quality over the previous records. One fairly continuous event at about 2.6 seconds was recorded, but no other deep events.

A Musgrave-type expanded spread to obtain velocity information (Musgrave, 1962) was conducted between SP110 and SP118, centred on SP114 (Plate 29). The results were incorporated in the t:$\Delta$t analysis on Traverse A.

Traverse B was shot using seven shot-holes with a 15-metre spacing and 37 metres deep, and 24 geophones per trace in line with the traverse at an interval of 6 metres. Drilling was commenced on Traverse D at SP1101 using a shot-hole arrangement of seven holes in line with the traverse at a spacing of 15 metres drilled to a depth of 37 metres. From SP1105 the number of holes per shot-point was reduced to five and from SP1132 the hole depth was reduced to 30 metres. These changes were both in the interest of economy, and they did not reduce record quality appreciably. The number of holes was further reduced to three from SP1181. No deep events had been obtained up to this point, and a three-hole pattern was quite adequate to record the shallow events. The shot-hole arrangement of three holes in line parallel to the traverse 15 metres apart and 30 metres deep was then used to the end of Traverse D at SP1298.

The initial geophone arrangement on Traverse D was 16 per trace in line with the traverse with an interval of 3 metres or 6 metres up to SP1133. From SP1134 to the end of the traverse at SP1298, the pattern was 32 geophones per trace in two lines parallel to the traverse, 9 metres apart, and a geophone interval of 3 metres.

On Traverse D, SPs 1095-1100 were shot using five shot-holes in line with the traverse, 9.8 metres apart and 30 metres deep. There were 16 geophones per trace in line and spaced 3 metres apart. This part of the traverse was a later extension to Traverse D, and smaller spacings were used so that there would be no danger of filtering out some interesting deep events with steep dips. The same technique was used for Traverse E, a short cross traverse intersecting Traverse D at SP1105.

The two short traverses, F and G, were both shot using a pattern of three shot-holes in line with the traverse, 15 metres apart and 30 metres deep. On Traverse F there were 32 geophones per trace, 3 metres apart, in two lines of sixteen, 9 metres apart. On Traverse G, there were 16 geophones per trace, 3 metres apart in line with the traverse.

For the first part of the survey the slow AGC setting ("WB" on the 7000B equipment) was used for recording all reflection shots. As a result of tests at SP1166 on Traverse D, medium-speed AGC was considered more suitable for controlling the amplitude of the very strong "A" reflection and avoiding over-modulation of the magnetic tapes. Medium AGC was used for the remainder of the reflection shooting, that is on Traverses D (from SP1166 to SP1298), E, F, and G.

Refraction traverses

The shallow refraction Traverses X1, X2, and X3 were located close to the water bores at Nelia, Nonda, and Maxwelton respectively. A 30-metre geophone station interval was used, i.e. a spread length of 700 metres. Each traverse was two spreads in length with one station common or a total distance between the shot-points located at the two ends of each traverse of 1400 metres.

All the other refraction work, that is on Traverses A, C, D, P13, and P10, was shot using a 91-metre geophone station interval and a 2195-metre spread length. Charges varied from 4.5 to 450 kilograms depending on the distance from shot to spread, and the holes ranged in depth between 18 and 26 metres.

Some continuous refraction profiles and some refraction probes were shot in the course of the survey. A refraction profile here refers to that method of refraction shooting in which shot-points and geophone spread are shifted successively along the traverse, maintaining a constant offset of the shot-points from each end of the spread. Thus the same refractor is recorded on every record and continuous coverage of this refractor is obtained. By contrast, in the type of refraction probe employed the two shot-points are maintained in fixed positions at the ends of the traverse and the geophone spread is moved successively between them. Thus the offset distance is constantly varied and a range of refractors is recorded. If the distance between the end shot-points is great enough all refractors to basement are recorded.

Refraction probes were shot on Traverse A between SP185 and SP213, on Traverse C between SP500 and SP510, on Traverse D between SP1178 and SP1200, on Traverse P13 between SP2486 and SP2514 and on Traverse P10 between SP2786 and SP2814. For the probes on Traverses A, C, and D, the geophone spread of 2195 metres or four shot-point intervals in length was moved successively by three shot-point intervals, so that there was 549 metres of overlap between adjacent records. On Traverses P13 and P10 the overlap was reduced, in the interest of economy, to one geophone, so that the spread, four shot-point intervals long, was moved successively by four shot-point intervals.

Refraction profiles were shot on Traverse D between SP1112 and SP1147 and on Traverse P13. The former employed a constant offset distance of the shots from the geophone spread of 1097 metres. The spread of geophones was four shot-point intervals in length and was moved successively by three intervals, giving again an overlap of 549 metres between adjacent records. Two profiles were surveyed on Traverse P13, one aimed at profiling the 2900-metres/sec refractor and one the 3540-metres/sec refractor recorded on the refraction probes. The former employed a 2195-metre geophone spread, a constant offset distance of 1097 metres, and an overlap between adjacent spreads of

549 metres. The latter was shot with 3540-metre spreads, a constant offset of 3292 metres and an overlap between adjacent spreads of one geophone only.

For all the refraction shooting referred to above, the geophone group was a line of four geophones at right angles to the traverse and with an interval of 6.7 metres. The shot-hole pattern was always either a single hole or a line of holes at right angles to the traverse.

## Offset reflection/refraction profiles

Offset reflection/refraction shooting was conducted on Traverse D between SP1240 and SP1252 and between SP1283 and SP1290, on Traverse F between SP1508 and SP1515, and on Traverse G between SP2106 and SP2115.

During the course of shooting a normal split-spread reflection traverse several kilometres long, additional shots were fired from the two end shot-points into each reflection spread so that records were obtained, shooting in both directions, for all shot-to-geophone distances from zero to the approximate length of the traverse. It was thus aimed to record the transition of reflection events into refraction events and to measure the refraction velocities associated with reflections.

# 6. RESULTS AND INTERPRETATION

## Reflection Traverse A

About 72 kilometres of continuous reflection profiling was shot on Traverse A (Plate 2). The results obtained on the traverse range from poor to fair (Plate 7). Generally fair results were obtained in that section of the traverse south of the Flinders River, while to the north of the river reflected events were either very poor or non-existent. The difference in results may be due in part to differing soil conditions. South of the river there are flat blacksoil plains while to the north the surface is sandy and in places lateritic.

As already indicated, this traverse was surveyed in order to investigate the northwest end of the Tangorin Gravity Depression for extent of Palaeozoic sedimentation. However, only one persistent reflector was recorded on the traverse and this is interpreted as representing horizon "A". Apart from multiple events arising from horizon "A" no reliable deeper events were recorded. Between shot-points 108 and 133 (Plate 2) horizon "A" exhibits a southerly dip component, the event occurring at 0.65 seconds at SP108 and at 0.55 seconds at SP133. Between SP133 and SP143 the event is of poor quality and lacks good continuity, but it appears to be fairly horizontal. Over the interval between SP143 and SP155 a westerly dip component is indicated, the event occurring at 0.54 seconds at SP143 and at 0.59 seconds at SP155. The dip is reversed from SP155 to SP159 where the main event occurs at 0.57 seconds. From SP159 to SP227 the main event loses its character and continuity. Where the main event can be identified, as from SP170 to SP174 and from SP180 to SP190, it exhibits a southerly dip component, occurring at 0.47 seconds at SP180 and at 0.43 seconds at SP190. Various shallow events occur along the traverse but they lack both continuity and character. Depths obtained using velocities calculated from a t:$\Delta$t analysis carried out on Traverse A indicate a shallowing of horizon "A" from 900 metres in the south to about 600 metres in the north.

Refraction Traverses A and C

A refraction probe was carried out between SP185 and SP213 on Traverse A. Since the object of the survey was to determine the existance of a Palaeozoic section, the shot-points were kept fixed at SP185 and SP213 and the geophone spread was moved successively along the traverse in an attempt to record the deepest refractor possible.

A plot of results (Plate 19) indicated a single, continuous refractor with a velocity of 5578 metres/sec. The time-distance curves obtained from the overburden indicated a continuous velocity increase with depth, and it has not been possible to identify overburden refractors.

Gardner intercept and delay time curves (Gardner, 1939) for forward and reverse shots were drawn for the refractor using a velocity of 5578 metres/sec. A close inspection of the intercept curves indicated that an offset of 488 metres gave a good match of the forward and reverse curves. The parallelism of these two curves when plotted with an offset of 488 metres indicated that the refractor velocity assumed (5578 metres/sec) is correct. Geophone delay curves were computed from the intercept curves drawn in the offset position.

The depth of the refractor was estimated as 610 metres.* The delay curves indicate a gentle south dip, conforming to the regional trend. Because of its velocity the refractor has been interpreted as basement.

If this interpretation is correct then a comparison of refraction depth estimates with those obtained from reflection work on Traverse A would appear to indicate that no appreciable thickness of Palaeozoic section exists in the area. It is possible that in this area only a thin veneer of Upper Permian exists and that horizon "A" represents reflection either from basement or from the top of the veneer of Upper Permian.

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* Depth estimates for the refractors on Traverses A, D, P10, and P13 were made using single average overburden velocities. The average velocities used were estimated. Although these estimates were guided by some velocity information obtained from t:$\Delta$t analyses of reflections on Traverses A and D, the average velocities used are only rough approximations, so depth estimates could be appreciably in error.

Traverse C (Plate 2) was surveyed close to an outcrop of metamorphic basement near Stawellton Homestead. This consisted of a short refraction probe shot between SP500 and SP510 in order to measure basement velocity. A velocity of 5390 metres/sec was recorded, which tends to confirm that the refractor recorded on Traverse A is basement (Plate 20). The depth of the refractor was estimated at 150 metres.

Reflection Traverse B

Traverse B (Plate 2) was surveyed for 6 kilometres west from SP163 on Traverse A. The purpose of this traverse was to determine whether horizon "A" deepens to the west. As on Traverse A, the only persistent event recorded was the one representing horizon "A" (Plate 8). No reflected events were recorded between SP901 and SP898 where the traverse crossed the channels of the Flinders River. Elsewhere on the traverse the main event, which occurs at about 0.54 seconds, appears to be horizontal with minor undulations. Indications of some shallow events can be seen on the more central traces of most records.

Reflection Traverses D and E

Traverse D (Plate 2) was surveyed from about 6 kilometres east of Julia Creek to about 20 kilometres west of Richmond. Continuous reflection profiling was carried out over the following intervals: SP1095 to SP1115; SP1132 to SP1200; SP1226 to SP1252; SP1283 to SP1298; the results are presented on Plates 9, 10, and 11.

A consistent reflection is recorded along Traverse D, which is probably fairly strong but which is often of poor quality because it becomes very shallow and consequently is interfered with by noise. It varies between times of 0.3 seconds at the western end to 0.55 seconds at the eastern end. It is closely associated with a refractor with a velocity of about 5500 metres/sec (see also under "Refraction Traverse D") and is therefore regarded as a reflection from basement. It is also probably the equivalent of the "A" reflection recorded in the eastern part of the area.

The section of traverse between SP1095 and SP1115 covered the western margin and the supposed crest of the St Elmo Structure. Because of the shallow basement in this region, the results obtained are poor. Between SP1095 and SP1101, the "A" reflection occurs at 0.375 seconds and appears to be almost horizontal. A shallow, horizontal event occurring at about 0.31 seconds can also be seen on the records. Continuous events are absent from the rest of the section between SP1101 and SP1115 (except for some very deep events) but there are indications of events at about 0.2 seconds on the central traces of records between SP1107 and SP1114.

The main reflection on Traverse E, which was surveyed perpendicularly to Traverse D through SP1105, exhibits a southerly dip component, occurring at 0.235 seconds under SP1805 and at 0.27 seconds under SP1800 (Plate 12).

Reflection profiling was recommenced at SP1132 on Traverse D to cover the eastern flank of the St Elmo Structure, and was continued to SP1200 in the central part of the Nonda Gravity Depression. Between SP1133 and SP1142, an event which is believed to originate from the basement occurs at 0.31 seconds (Plate 10). This event has a slight easterly dip component. The easterly dip increases sharply between SP1142 and SP1146, the main event occurring at 0.50 seconds under SP1146. From SP1146 to SP1169 the event remains almost horizontal and then takes a westerly dip component, occurring at 0.46 seconds under SP1176. Between SP1177 and SP1200 the event is very poor and no longer continuous. It can however be traced over intervals of up to about 1½ kilometres. Over the intervals the event appears to remain horizontal. A poor, shallow event, occurring at between 0.3 and 0.35 seconds, can be seen over most of the section between SP1145A and SP1200. This shallow event suffers a great deal of interference from noise originating from the shot.

Two further sections of Traverse D, from SP1226 to SP1252 and from SP1283 to SP1297, were shot using reflection profiling. The results obtained range from poor to fair. In both these sections the main event, which occurs between 0.5 and 0.55 seconds, appears to be almost horizontal. Offset reflection/refraction shooting was also employed on both these sections of traverse. Although the quality of results obtained (Plates 13 and 14) is not very good, they appear to indicate that the main event can be correlated with a refractor whose velocity is about 5800 metres/sec. This tends to confirm that the main event originates at or near basement.

At some places along traverse D, deep reflections are recorded below horizon "A". West of SP1101, reflections are recorded between 0.8 and 2.0 seconds (Plates 9 and 28). It is possible that the basement rocks to the Mesozoic section on the west side of the St Elmo Structure are Proterozoic sediments. Between SP1095 and SP1101 strong events occur after 4 seconds; they dip steeply to the east, but it is not possible to say what they represent.

In order to obtain a three-dimensional picture of some further deep events occurring between SP1103 and SP1111, Traverse E was shot perpendicular to Traverse D through SP1105 (Plate 12). The main deep events present, the record times at which they occur, and the direction of their dip components are summarised in Table 3. Events 3 and 4 are horizontal on both traverses and are therefore likely to be genuine reflections from within the basement. Because of their straightness and apparent dip, events 1 and 2 are likely to be reflected refractions, the refracted events probably being reflected back from a fault plane. This fault plane would be to the northeast of Traverses D and E. The velocity of the refraction is approximately 6100 metres/sec.

TABLE 3

DEEP EVENTS NEAR WEST END OF TRAVERSE D AND ON TRAVERSE E

| Event | Traverse | Shot-point | Record time, seconds | Dip component |
|---|---|---|---|---|
| 1 | D | 1104 | 1.845 | W |
| | | 1105 * | 1.690 | |
| | | 1107 | 1.355 | |
| | E | 1800 * | 1.680 | S |
| | | 1807 | 1.340 | |
| 2 | D | 1105 | 1.800 | W |
| | | 1107 | 1.485 | |
| | E | 1800 | 1.798 | S |
| | | 1807 | 1.475 | |
| 3 | D | 1106 | 1.910 | Zero |
| | | 1107 | 1.915 | |
| | E | 1803 | 1.905 | Zero |
| | | 1801 | 1.905 | |
| 4 | D | 1111 | 3.500 | Zero |
| | | 1106 | 3.486 | |
| | E | 1801 | 3.500 | Zero |
| | | 1806 | 3.500 | |

* SP1105 Traverse D is the same point as SP1800 Traverse E.

## Refraction Traverse D

One refraction profile and one refraction probe were shot on Traverse D. The profile was shot between SP1112 and SP1147 and the probe between SP1178 and SP1200. The profile was shot in order to delineate the St Elmo Structure, while from the probe it was hoped to determine the relation between basement and the main reflector recorded on Traverse D.

Relative intercept curves for forward and reverse shots were drawn up for the whole of the traverse covered by the refraction profile (Plate 21). The mean of these curves indicates that the refractor being followed dips gently to the east between SP1114 and

SP1142 and the dip then increases sharply between SP1142 and SP1145. Three velocity changes occur along the traverse, possibly indicating lateral changes in basement composition. Between SP1115 and SP1121 the refractor velocity recorded is about 5150 metres/sec, between SP1122 and SP1133 about 5520 metres/sec, and between SP1133 and SP1145 about 5610 metres/sec.

Plate 28 is a diagrammatic section across the St Elmo Structure drawn up by using data from both reflection and refraction results. In the region between SP1101 and SP1106 the shallow reflections associated with the basement are very poor or non-existent (Plate 9). It is believed that a fault zone occurs in the region between SP1101 and SP1103, the downthrow of the fault being to the west. The St Elmo Structure appears to be a broad, asymmetric structure with a gently dipping eastern flank; however, the dip increases sharply on the eastern margin, as can be seen on both the refraction profile (Plate 21) and the reflection profile (Plate 10).

On the refraction probe shot between SP1178 and SP1200 a near-surface velocity of about 2380 metres/sec was recorded (Plate 22). A higher velocity of about 5640 metres/sec was recorded at a depth of about 600 metres. Gardner intercept curves were drawn up for the high-velocity refractor. There were no common features on the forward and reverse curves which would give an indication of offset, but using a calculated value of the offset of 430 metres, a mean intercept curve indicates that apart from local irregularities the refractor has no appreciable dip in the traverse direction.

A comparison of the reflection and refraction results obtained over the region between SP1178 and SP1200 indicates that the main reflection recorded originates at or near basement. This, therefore, precludes the possibility of there being a considerable thickness of Palaeozoic sediments in the area.

## Reflection Traverse F

Traverse F (Plate 2) was surveyed for about 8 kilometres in the centre of the gravity low in north-central JULIA CREEK. The results obtained (Plate 15) are similar in quality to those obtained on Traverses D and E. Only one shallow event was recorded and this has a slight easterly dip, occurring under SP1501 at 0.30 seconds and under SP1511 at 0.32 seconds. Offset reflection/refraction shooting (Plate 16) carried out on this traverse indicated that the event can be correlated with a refractor whose velocity is approximately 5800 metres/sec.

## Reflection Traverse G

This traverse was surveyed in the deepest part of the southern end of the Nonda Gravity Depression. Both reflection profiling (Plate 17) and offset reflection/refraction shooting (Plate 18) were carried out. Three separate, continuous events are seen on the reflection section. All three exhibit a southerly dip component between SP2114 and SP2105, and are more or less horizontal between SP2105 and SP2101. The deepest event, horizon "A", occurs at 0.75 seconds in the north and 0.79 seconds in the south. Depths obtained using velocities from a t:$\Delta$t analysis carried out on Traverse A indicate a thickening of section above horizon "A" from about 1070 metres in the north to 1160 metres in the south.

The results of the offset reflection/refraction shooting were not conclusive. An examination of the sections indicates that horizon "A" probably can be correlated with a refractor whose velocity is about 5500 metres/sec.

Refraction Traverses P13 and P10

A refraction probe was surveyed in the Bowen Downs area between SP2486 and SP2514 on Traverse P13 (Plate 3). The shot-points were kept fixed at SP2486 and SP2514 and the geophone spread was successively moved along the traverse in order to record all refractors to basement. When this had been completed an attempt was made to survey continuous profiles on some of the refractors recorded.

Three refractors were recorded along the traverse, with velocities of approximately 2900, 3490, and 5760 metres/sec. Two long offset shots using a maximum shot-to-geophone distance of 19 kilometres recorded a refractor with a velocity of about 5490 metres/sec. It is therefore believed that the 5760-metres/sec refractor represents basement. The mapped profile of the 3490-metres/sec refractor is essentially horizontal (Plate 23). A general dip to the southeast is evident on the basement refractor profile (Plate 24). The mean Gardner intercept is approximately 884 milliseconds at SP2494, 878 milliseconds at SP2496, and 915 milliseconds at SP2508.

Approximate estimates of the depths of the refractors on Traverse P13 were obtained from intercept times and are tabulated below.

| Refractor velocity | Average vertical velocity assumed | Depth at SP2486 NW | Depth at SP2514 SE |
|---|---|---|---|
| 2900 m/s | 2400 m/s | 380 metres | 150 metres |
| 3490 m/s | 2650 m/s | 610 metres | 594 metres |
| 5760 m/s | 3185 m/s | 1600 metres | 1890 metres |

A northwest component of dip along the traverse is evident for the shallowest refractor, and a southeast component for the deepest, or basement, refractor.

Reflection profiling carried out on this traverse by Amerada shows that horizon "A" occurs at a depth of about 900 metres. This means that 600 to 900 metres of Permian and possibly pre-Permian sediments are present in this area, if horizon "A" represents a Permian reflector.

A similar refraction probe was surveyed between SP2786 and SP2814 on Traverse P10 (Plate 3). On this traverse four refractors were recorded with velocities of about 2750, 3440, 4650, and 5750 metres/sec (Plate 25). Estimates of depths, made using the intercept times, for the various refractor velocities are listed below.

| Refractor velocity metres/sec | Average vertical velocity assumed metres/sec | Depth at SP2786 NW | Depth at SP2814 SE |
|---|---|---|---|
| 2750 | 2320 | 120 metres | 107 metres |
| 3440 | 2620 | 460 metres | 400 metres |
| 4650 | 3170 | 1620 metres | 1400 metres |
| 5750 | 3660 | 2150 metres | 2960 metres |

4650 metres per second is a velocity in the range normally associated with Palaeozoic rocks, and it is thus assumed that the refractor with this velocity probably lies within the Palaeozoic Drummond Basin sequence.

Refraction results on Traverses P10 and P13 are summarised in Plate 26 which is a correlation diagram in the east-west direction showing the refraction velocities recorded on each traverse. The depth scale provided is intended only to indicate the order of depth involved. The drilling of Thunderbolt No. 1 well (Plate 3) has confirmed the existence of Permian and possibly older Palaeozoic sediments on Traverse P13. It can be seen from Plate 26 that there is a rapid thickening of Palaeozoic sediments to the east. The 5750-metres/sec refractor recorded on Traverse P13 probably corresponds with the volcanic rhyodacite penetrated in Thunderbolt No. 1 at a depth of 1608 metres.

Plate 27 is a diagram showing alternative correlations of refractors between Traverse P10 and P13 and Exoil's refraction line 3 near Lake Galilee (Exoil, 1962b). The drilling of Lake Galilee No. 1 well proved the existence of a sedimentary section in excess of 3350 metres in the Lake Galilee area; therefore the 5384-metres/sec refractor recorded on line 3 at a depth of 2195 metres lies within the Palaeozoic Drummond Basin sequence.

## Refraction Traverses X1, X2, X3

The positions of these traverses are shown on Plate 2. A refractor with a velocity of about 3050 metres/sec was recorded over a distance from 275 to 490 metres on each traverse, firstly as a second and then as a first arrival. It is thought that this refraction event originates from the Toolebuc Member of the Wilgunya Formation. As the attenuation rate was very high and the event did not persist over a reasonable distance it was decided that this was not a good model to use for experimental work on thin refractors.

## 7. CONCLUSIONS

The survey demonstrated that in the area investigated between Julia Creek and Richmond, in the Nonda and Tangorin Gravity Depressions, basement is fairly shallow and that no appreciable thickness of Palaeozoic sediments can be expected. It demonstrated that the Nonda Gravity Depression results in part from a thickening of Mesozoic sediments east of the St Elmo Structure. In general the Mesozoic sediments have a dip to the south in the area, increasing in thickness from 520 metres near Woodlands Homestead to 1160 metres near Dundee Homestead, a distance of about 160 kilometres. The reflection work showed that over most of the region variations in sedimentary thickness bear little relation to gravity anomalies, thereby indicating that the gravity pattern is probably dominated by density changes within the basement. It was also shown that the St Elmo Structure is a broad, relatively flat structural high, probably with a faulted western margin.

The work in the Bowen Downs area indicated that in that area the refraction method is more successful in determining the depth to basement than the reflection method. The refraction results show that the Palaeozoic sequence of the Drummond Basin rapidly thins westward in the Bowen Downs area.

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# APPENDIX A

## STAFF AND EQUIPMENT

### Staff

| | |
|---|---|
| Party Leader | P. Jones |
| Geophysicists | J.C. Branson<br>A.R. Brown<br>W.J. McAvoy |
| Observers | J.K.C. Grace<br>G.S. Jennings |
| Surveyors | N. Vaughan<br>E. Britten |
| Shooters | R.D.E. Cherry<br>H. Pelz |
| Toolpushers | J. Keunen<br>B.G. Findlay |
| Drillers | E.D. Lodwick<br>W.F. Whitburn |
| Drilling Assistant | L.A.C. Keast |
| Mechanics | E. McIntosh<br>D. McIntyre |
| Clerk | S.C. Wright |

The maximum number of wages hands employed at any one time was 16. These included cook, cook's offsider, field hands, drill helpers.

### Equipment

| | |
|---|---|
| Magnetic Recorders | PMR-20 (F.M.)<br>Electro-Tech D.S. 7-7 |
| Seismic Amplifiers | T.I. 7000B |
| Oscillograph | S.I.E. TR06 |
| Programmed gain unit and prefilters | C.G.G. |
| Transceivers | Traeger T.M.2(3), Pye (3) |
| Geophones | Hall-Sears HS-J 14-cycle (1568<br>Electro-Tech 4.5-cycle (104) |
| Cables | Vector 1/3 mile |
| Printing Machine | Metem 20 |
| Drills | Mayhew 1000 (2), Carey (1) |
| Workshop | One Bedford chassis ZSU 149 with alternator, compressor, greasing unit, arc welder, grinding wheels and hand tools. |

### Vehicles

Vehicles

| Function | Type | Registration No. |
| --- | --- | --- |
| Party Leader's | International AB 120 4 x 4, 1-ton utility | ZSU 097 |
| Recording Truck | International AB 120 4 x 4, 1-ton utility | ZSU 092 |
| Personnel Carrier | Land Rover Station Wagon | ZSM 480 |
| " " | " " " " | ZSM 481 |
| Cable Vehicle | " " LWB | ZSM 334 |
| " " | " " " | ZSM 347 |
| " " | " " " | ZSM 377 |
| Flat Top | Bedford, 5-ton, 4 x 4 | ZSU 111 |
| " " | " " " | ZSU 063 |
| Water Tanker | " " " | ZSU 013 |
| " " | " " " | ZSU 194 |
| " " | " " " | ZSU 095 |
| " " | " " " | ZSU 109 |
| Shooting Truck | " " " | ZSU 108 |
| Workshop | " " " | ZSU 149 |
| Carey Rig | " " " | ZSU 110 |
| Mayhew Rig | International R 190, 4 x 4 | ZDA 093 |
| " " | " " " | ZDA 064 |
| General Carrier | International AB 130 4 x 4, 1½-ton utility | ZSU 188 |

# APPENDIX B

## PARTY OPERATIONS

### General

| | |
|---|---|
| Sedimentary basin | Northern Eromanga |
| Areas of survey | Richmond-Julia Creek Aramac-Muttaburra |
| Camp sites near | Richmond<br>Nonda<br>Bowen Downs |
| First camp established | 5 May 1966 |
| Last camp struck | 1 December 1966 |
| Kilometres of traverse surveyed | 251 |
| Kilometres of traverse shot | 217 |
| Topographic survey control | National Mapping 4-mile series, Dept of the Interior benchmarks, Queensland State Datum |
| Total footage drilled | 228,594 (69,675 metres) |
| Total number of holes | 2332 |
| Explosives used | 37,000 kg Geophex |
| Explosives used | 5500 kg ammonium nitrate |
| Datum levels for corrections | |
| Traverses A, B, P10, P13 | 700 ft (213.4 metres) |
| Traverses D, E, F, G | 400 ft (121.9 metres) |
| Traverse C | 1000 ft (304.8 metres) |
| Weathering velocity | 610 metres/sec |
| Sub-weathering velocity | 2134 metres/sec<br>2286 metres/sec |
| Static correction method | Uphole times checked by first breaks |
| Source of velocity distribution | t:$\Delta$t analysis |
| Shot-point interval | 549 metres |

### Reflection shooting data

| | |
|---|---|
| Geophone group interval | 46 metres |
| Geophone patterns | Unit group of 8 geophones with up to 6-metre spacing, connected in various combinations from 16 to 48 |
| Shot-hole patterns | 3, 5, or 7 holes in line parallel to traverse with spacing between 9 and 21 metres |

| | |
|---|---|
| Number of shot-points shot | 306 |
| Kilometres of traverse surveyed | 167 |
| Common shooting depth | 24-36 metres |
| Common charge sizes | 4½ to 23 kg per hole |
| Usual recording filters | 18 - 120K |
| Usual playback filters | 24 - 75K |
| Number of offset reflection traverses | 4 |

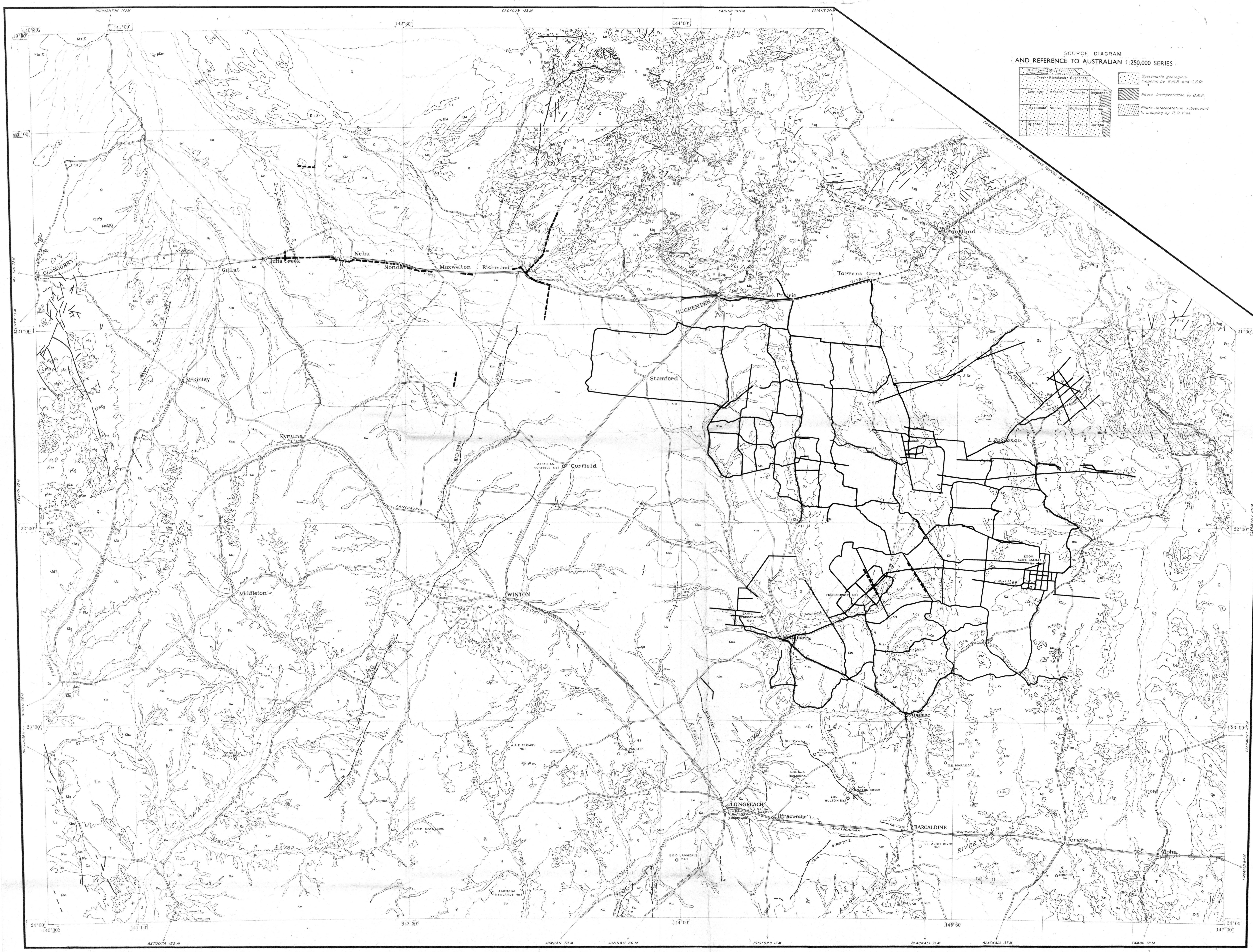
Refraction shooting data

| | |
|---|---|
| Geophone group interval | 91.4 metres (30.5 metres on Traverses X1, X2, X3) |
| Geophone pattern | 4 per trace in line perpendicular to traverse, spacing 6.7 metres |
| Number of shot-points shot | 62 |
| Number of refraction traverses | 9 |
| Charge sizes | 2.3 - 454 kg |
| Usual recording filters | 0 - 75K<br>0 - 47K |
| Usual playback filters | 0 - 75K<br>0 - 47K |
| Maximum shot-to-geophone distance | 19 kilometres |
| Weathering control | From reflection shooting data (calculated at shot-points only from uphole times) and from shallow refraction shots |

PLATE I

# GEOLOGICAL MAP
# NORTHERN EROMANGA BASIN

QUEENSLAND
AUSTRALIA

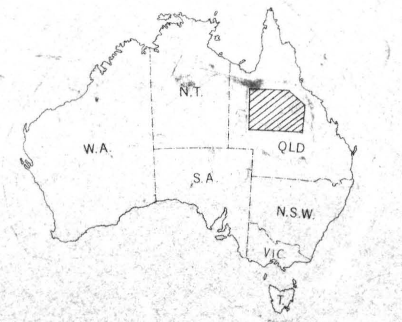



## Reference

| | | | | |
|---|---|---|---|---|
| CAINOZOIC | QUATERNARY | | Qa | Alluvium |
| | | | Q | Sand, soil, silt, clay, rubble |
| | UNDIFFERENTIATED | | Czb | Basalt |
| | TERTIARY | | T | Sandstone, mudstone, conglomerate, limestone |
| MESOZOIC | LOWER TO UPPER(?) CRETACEOUS | Winton Formation | Kw | Mudstone, labile sandstone, sandy limestone, coal, intraformational conglomerate |
| | LOWER CRETACEOUS | Rolling Downs Group: Mackunda Formation | Klm | Labile sandstone, mudstone, sandy limestone, coquinite |
| | | Wilgunya Formation | | |
| | | Allaru Member | Kla | Mudstone, siltstone, cone-in-cone limestone |
| | | Toolebuc Member | Klo | Limestone, calcareous shale, coquinite |
| | | Coreena Member | Klc | Siltstone, labile sandstone, mudstone |
| | | Ranmoor Member | Klq | Mudstone, carbonaceous shale |
| | | Doncaster Member | Kld | Mudstone, glauconitic mudstone and siltstone, minor concretionary limestone and quartzose sandstone |
| | | Gilbert River Formation | Klg | Conglomeratic sandstone, polymictic conglomerate, quartzose sandstone |
| | JURASSIC TO LOWER CRETACEOUS | Ronlo Beds | J-Kr | Quartzose and labile sandstone, mudstone |
| | | | J-K | Conglomerate, sandstone, mudstone, limestone (undifferentiated erosional residuals of Cloncurry Block) |
| | UPPER JURASSIC | Blantyre Sandstone | Jub | Quartzose sandstone, mudstone, coal |
| | MIDDLE JURASSIC | Birkhead Formation | Jmb | Labile sandstone, mudstone, siltstone |
| | LOWER JURASSIC | Hutton Sandstone | Jlh | Quartzose to sub-labile sandstone |
| | JURASSIC | | Jb | Siltstone, quartzose sandstone |
| | | | Ja | Quartzose to sub-labile sandstone, mudstone, siltstone |
| | MIDDLE TO UPPER TRIASSIC | Mooldyember Formation | Rm | Mudstone, siltstone, labile sandstone minor quartzose sandstone |
| | LOWER TO MIDDLE TRIASSIC | Clematis Sandstone | Re | Quartzose sandstone |
| | LOWER TRIASSIC | Dunda Sandstone | Rld | Labile to quartzose sandstone, mudstone, siltstone |
| | | Rewan Formation | Rlr | Mudstone, siltstone, labile sandstone |
| | | Warang Sandstone | Rlw | Quartzose sandstone, mudstone, siltstone |
| PALAEOZOIC | UPPER PERMIAN | Betts Creek Beds | Pub | Labile to quartzose sandstone, siltstone, mudstone, coal, carbonaceous shale |
| | | "Bandanna Formation" | Pua | Mudstone, labile sandstone |
| | LOWER(?) TO UPPER PERMIAN | Colinlea Sandstone | Pc | Quartzose to sub-labile sandstone, minor mudstone, coal |
| | LOWER PERMIAN | Boonderoo Beds | Plb | Mudstone, siltstone, labile sandstone, varves, tillite (?), carbonaceous mudstone |
| | UPPER CARBONIFEROUS TO LOWER PERMIAN | Joe Joe Formation | C-Pj | Mudstone, siltstone, labile sandstone, some varves |
| | SILURIAN TO CARBONIFEROUS | | S-C | Sediments of the Drummond Basin sequence and Broken River Rift |
| PRECAMBRIAN AND PALAEOZOIC | | | Pzm / Pzg | Metamorphics (m) and igneous rocks (g) of Townsville Hinterland |
| PRECAMBRIAN | | | p€m / p€g | Metamorphics (m) and igneous rocks (g) of Cloncurry Complex |

*Geological boundary*
*Anticline*
*Syncline*
*Fault grading to monocline (D,U indicates relative movement down, up)*
*Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes*
*Bedding trend lines* } *air-photo interpretation*
*Joints* }
*Oil exploration well*
*Water bore tapping post-Wilgunya aquifer*
*Water bore tapping Wilgunya or older aquifer*
*Principal roads and vehicle tracks*
*Railway*

Published by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjuction with the Geological Survey of Queensland. Topographic base compiled by the Bureau of Mineral Resources, Geology and Geophysics, from 1:250,000 Planimetric Series of the Division of National Mapping, Department of National Development and the Royal Australian Survey Corps.
Lambert Conformal Conic Projection.




SCALE 1:1,000,000

Miles / Kilometres



GEOPHYSICAL LEGEND

COMPANY TRAVERSES

B.M.R. FLINDERS RIVER SURVEY

TO ACCOMPANY RECORD No. 1970/52

Compiled 1966 by: R.R. Vine and I. Chertok
Drawn 1966 by: I. Chertok


F55/B3-57

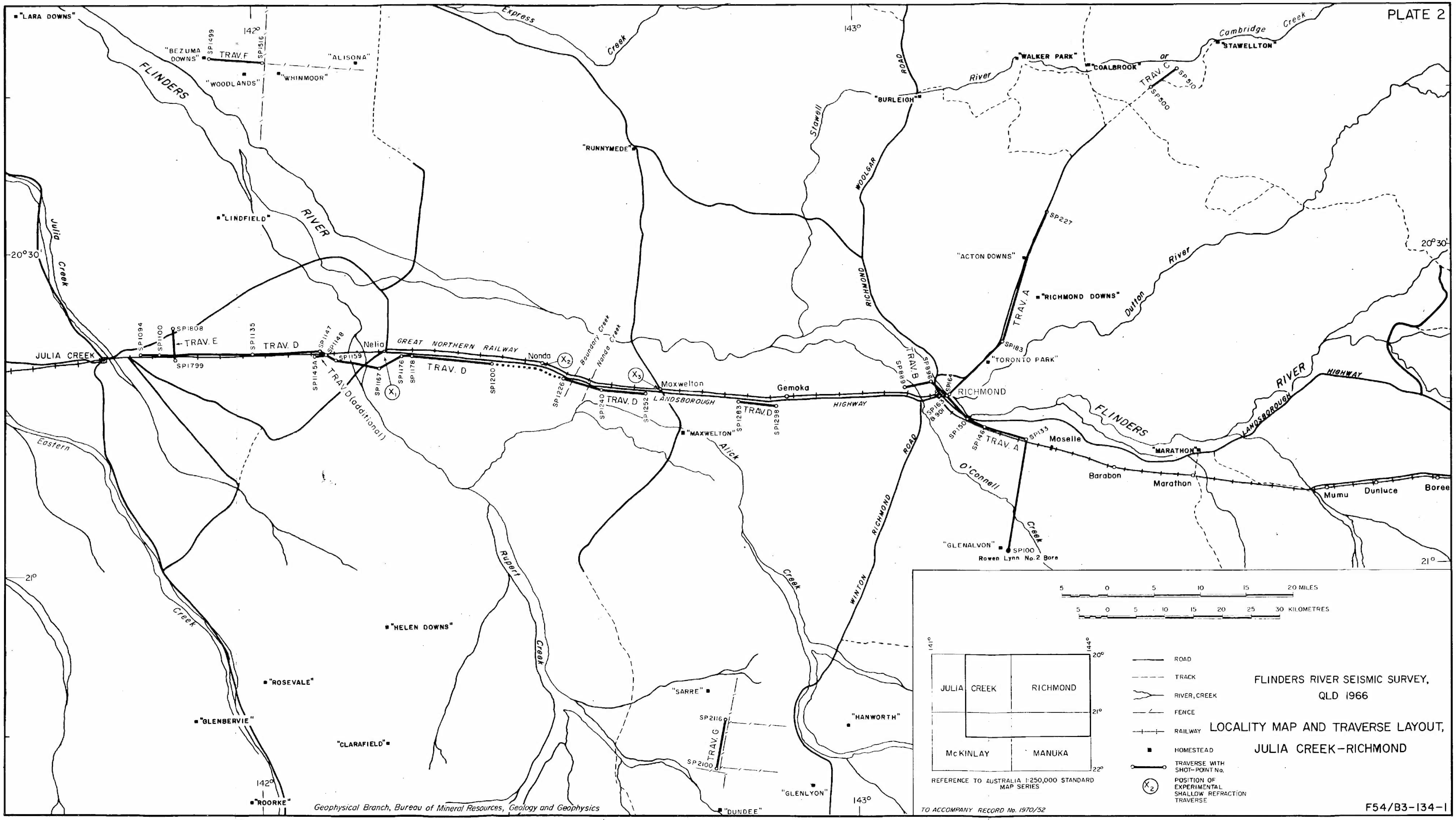
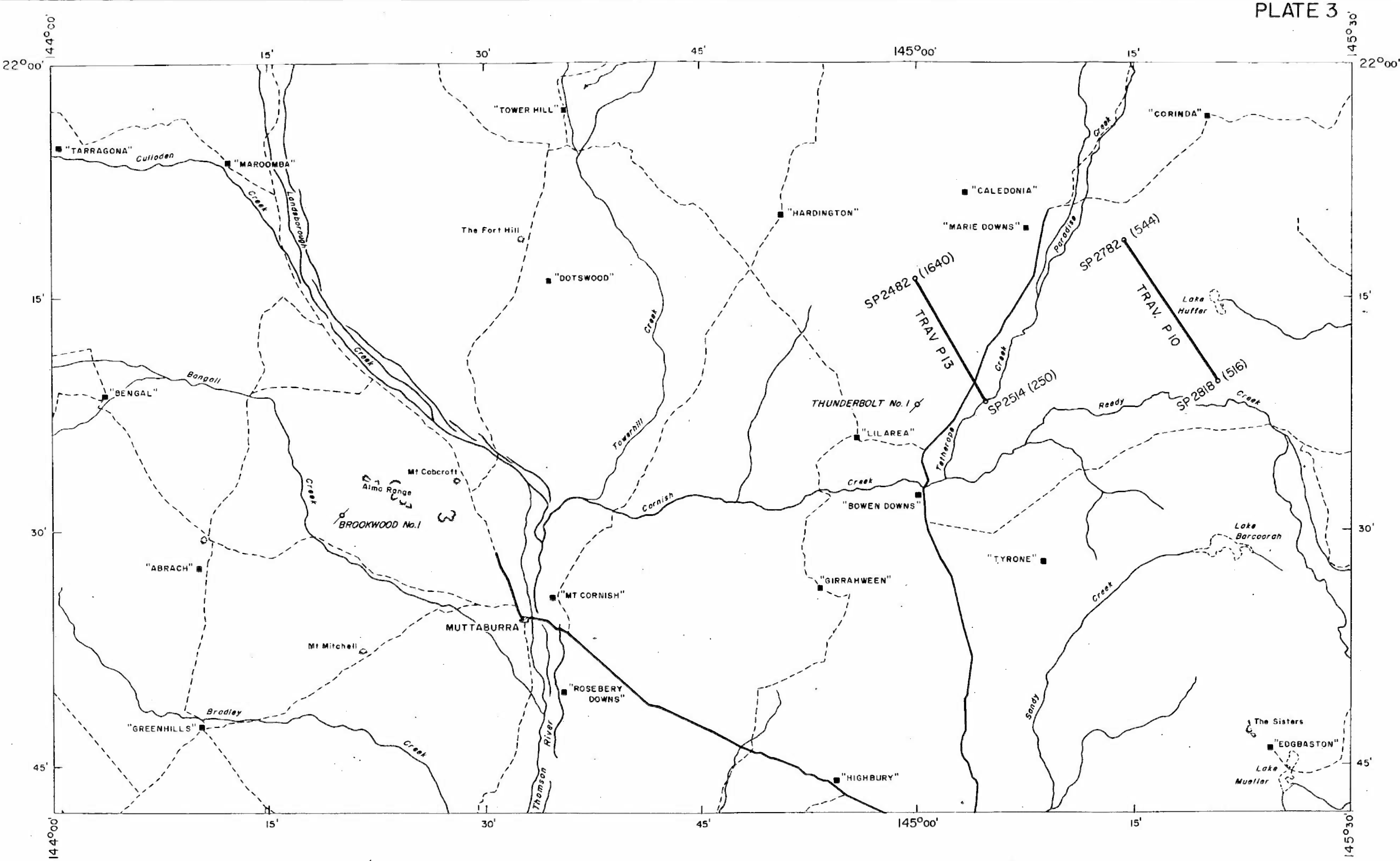


PLATE 2
FLINDERS RIVER SEISMIC SURVEY, QLD 1966
LOCALITY MAP AND TRAVERSE LAYOUT, JULIA CREEK–RICHMOND
ROAD
TRACK
RIVER, CREEK
FENCE
RAILWAY
HOMESTEAD
TRAVERSE WITH SHOT-POINT No.
POSITION OF EXPERIMENTAL SHALLOW REFRACTION TRAVERSE
5 0 5 10 15 20 MILES
5 0 5 10 15 20 25 30 KILOMETRES
JULIA CREEK
RICHMOND
McKINLAY
MANUKA
REFERENCE TO AUSTRALIA 1:250,000 STANDARD MAP SERIES
TO ACCOMPANY RECORD No. 1970/52
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics
F54/B3-134-1
"LARA DOWNS"
"BEZUMA DOWNS"
TRAV. F
SP1499
SP1516
"ALISONA"
"WOODLANDS"
"WHINMOOR"
FLINDERS
RIVER
"LINDFIELD"
Julia Creek
-20°30'
142°
143°
Express Creek
"RUNNYMEDE"
"WALKER PARK"
"COALBROOK"
"STAWELLTON"
Cambridge Creek
"BURLEIGH"
River
TRAV. C
SP510
SP500
Slawell
WOOLGAR ROAD
RICHMOND
SP227
"ACTON DOWNS"
"RICHMOND DOWNS"
TRAV. A
Dutton River
SP183
"TORONTO PARK"
20°30'
JULIA CREEK
SP1094
SP1100
SP1808
TRAV. E
SP1799
SP1135
TRAV. D
SP1147
SP1148
SP1159
SP1145A
TRAV. D (additional)
Nelia
GREAT NORTHERN RAILWAY
SP1167
SP1176
SP1178
SP1200
Nonda
Boundary Creek
Nanda Creek
SP1226
SP1240
SP1252
Maxwelton
LANDSBOROUGH
SP1283
SP1298
Gemoka
HIGHWAY
TRAV. B
SP889
SP896
SP164
SP163
SP901
RICHMOND
FLINDERS
RIVER
LANDSBOROUGH HIGHWAY
SP150
SP146
SP133
Moselle
"MARATHON"
Barabon
Marathon
Mumu
Dunluce
Boree
Eastern
"MAXWELTON"
Alick Creek
O'Connell Creek
"GLENALVON"
SP100
Rowen Lynn No. 2 Bore
ROAD
WINTON RICHMOND
21°
Rupert Creek
Creek
"HELEN DOWNS"
"ROSEVALE"
"GLENBERVIE"
"CLARAFIELD"
"SARRE"
SP2116
TRAV. G
SP2100
"HANWORTH"
"GLENLYON"
"DUNDEE"
"ROORKE"




## FLINDERS RIVER SEISMIC SURVEY, QLD 1966

# LOCALITY MAP AND TRAVERSE LAYOUT, MUTTABURRA

LEGEND

- BUILT-UP AREA
- HOMESTEAD
- RIVER OR CREEK
- PRINCIPAL ROAD
- TRACK
- (544) SHOT-POINT NUMBERS: AMERADA, BOWEN DOWNS SEISMIC SURVEY
- EXPLORATORY WELL

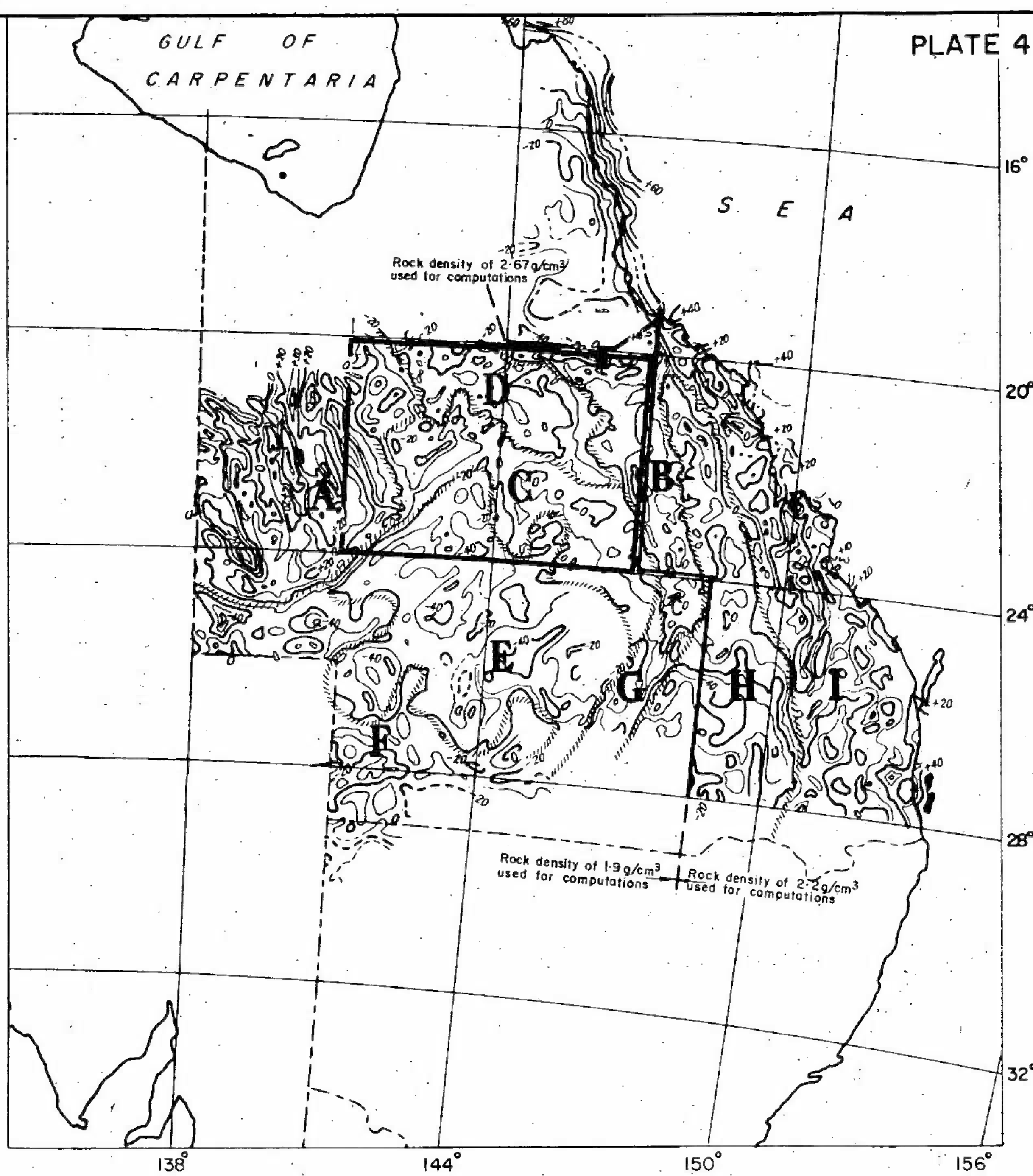
5 0 5 10 15 20 MILES
5 0 5 10 15 20 25 30 KILOMETRES

*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics*

*TO ACCOMPANY RECORD No. 1970/52*

F55/B3-56-1

PLATE 4




- A Cloncurry Regional Gravity High
- B Anakie Regional Gravity High
- C Muttaburra Gravity Ridge
- D Flinders Regional Gravity Low
- E Thomson Regional Gravity Low
- F Eulo Gravity Platform
- G Nebine Gravity Ridge
- H Bowen-Surat Regional Gravity Low
- I Coastal Gravity Complex
- ''''' Gravity Province Boundary

▬ Area covered in this report

# QUEENSLAND

# BOUGUER ANOMALIES AND GRAVITY PROVINCES

100 0 100 200 300 400 500 MILES

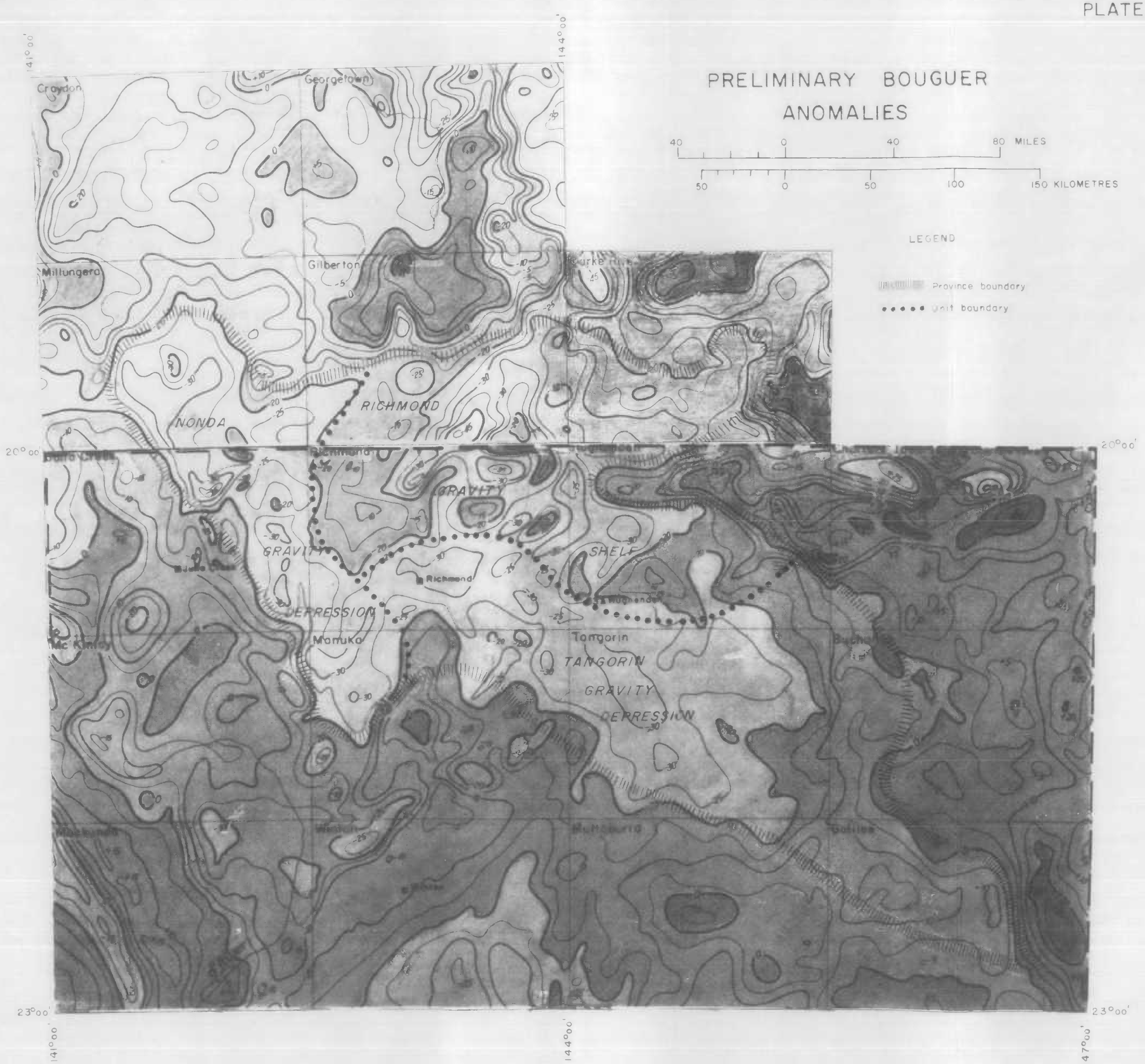
100 0 200 400 600 800 KILOMETRES

CONTOUR INTERVAL 10 MILLIGALS

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS Q/B2-12A

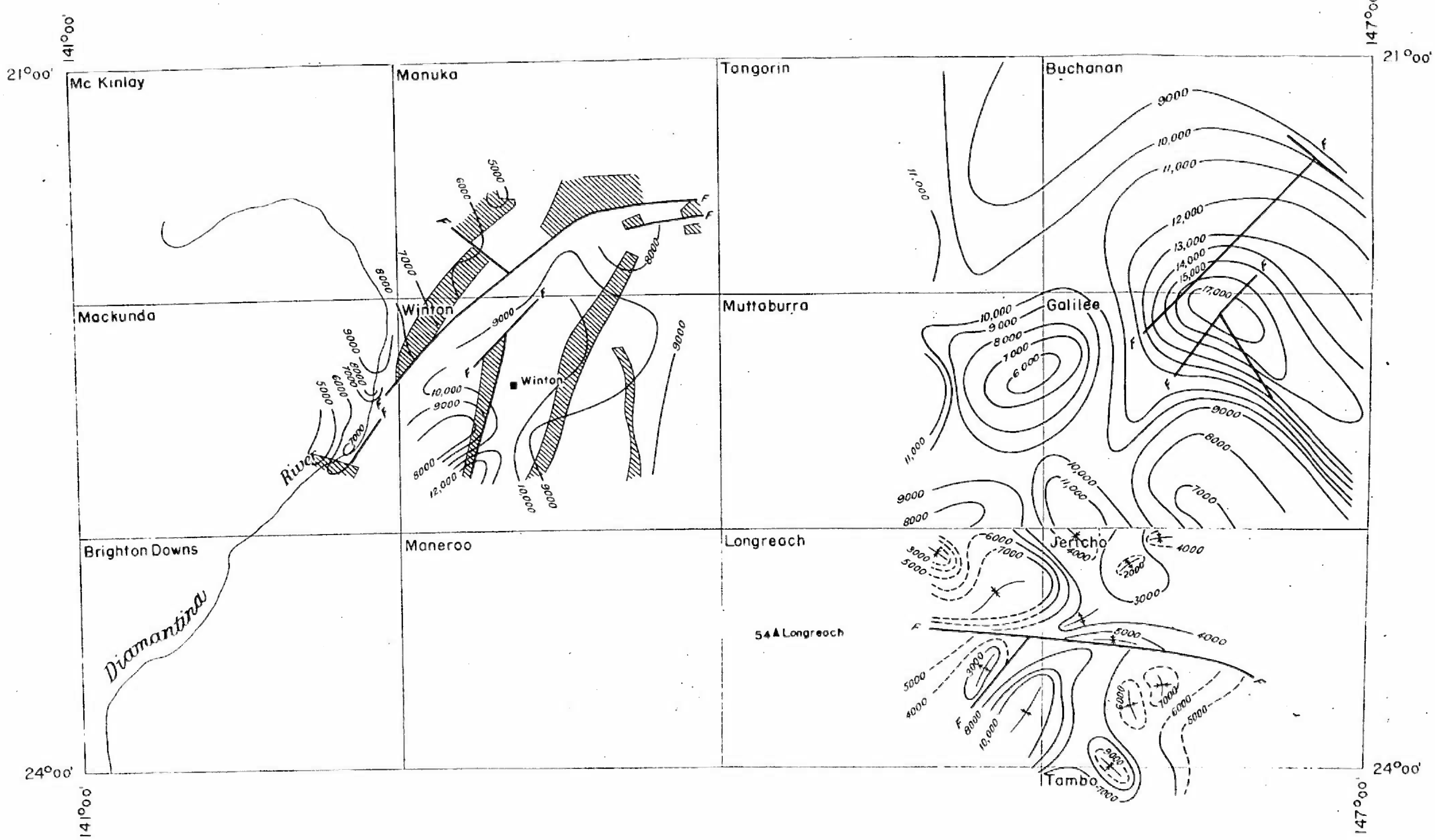
BASED ON 4/B0-1) To accompany Record No 1970/52

PLATE 5




To Accompany Record N° 1970/52 Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

F54/B3-176-1




LEGEND

- Anticlinal axis
- Synclinal axis
- —5000— Depth to basement
- "Basic mass"
- ——F Fault

Compiled from interpretations by Magellan Petroleum Corp. and Exoil N.L.

# AEROMAGNETIC INTERPRETATION
# MAGNETIC BASEMENT CONTOURS

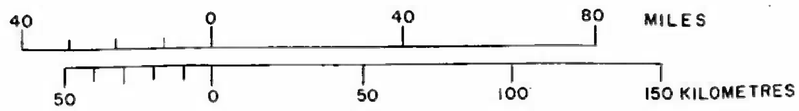



PLATE 7

## CORRECTED RECORD SECTION

**RECORDING INFORMATION**

*Magnetic Recorder*: PMR-20
*Amplifiers* : 7000B
*Prefilters*: 18c/s, 12dB/octave
*Filters* : 0-K120
*AGC* : W.B.
*Gain Initial*: -55, -60
*Final*: -20, -10
*Geophones*: HSJ-14c/s
*Geophone Station Interval* : 150'
*Geophone Pattern* :
SP100-SP203, 16/trace, 10' apart in line
SP204-SP227, 24/trace, 20' apart in line

*Shot Hole Pattern*:
SP100-SP203, 5 holes, 32' apart in line
Depth 69-75' to 114-120', Charge 5x15lb

SP204-SP227, 7 holes, 64' apart in line
Depth 112-120' Charge 7x20lb

**PLAYBACK INFORMATION**

*Filters*: 2/31-1/78
*AGC* : S
*Gain Initial*: -40
*Final*: -20
*Trip Delay* : 0·15s
*Compositing*: Nil

**VELOCITY INFORMATION**

t:Δt, Expanded spread at SP114

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1800 3600

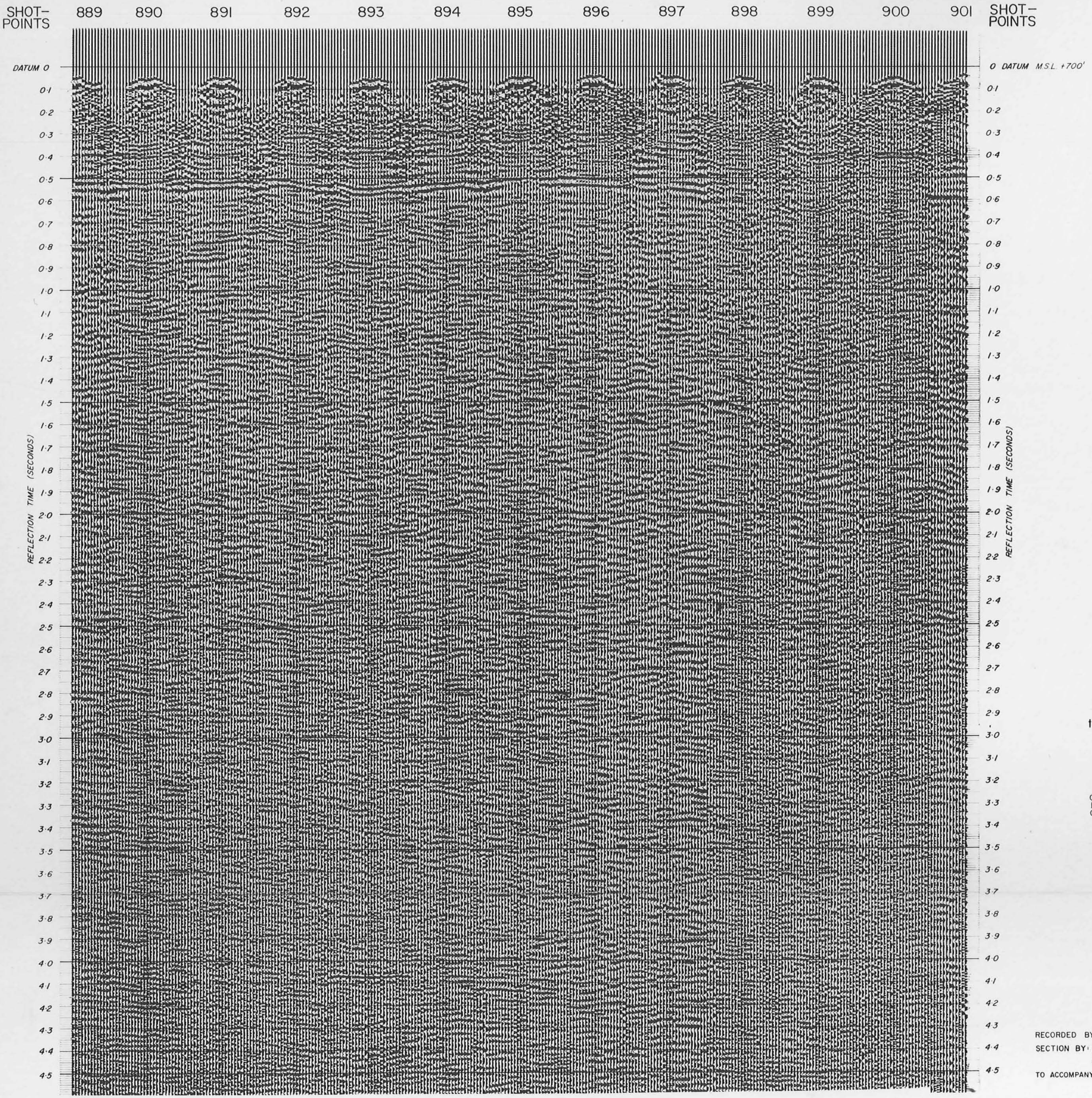
0 500 1000 METRES

## TRAVERSE A

RECORDED BY: *Seismic Party No. 1*
SECTION BY: *Bureau of Mineral Resources*
*Playback Centre SIE MS42*
TO ACCOMPANY RECORD No. 1970/52

F54/B3-19

# CORRECTED RECORD SECTION




RECORDING INFORMATION

*Magnetic Recorder:* PMR-20

*Amplifiers* : 7000B

*Prefilters:* 18c/s, 12dB/octave

*Filters* : 0-K120

*AGC* : W.B.

*Gain Initial:* -60 to -70

*Final:* -10

*Geophones:* HSJ-14c/s

*Geophone Station Interval:* 150'

*Geophone Pattern:*

24/trace, 20' apart in line

*Shot Hole Pattern:*

7 holes, 50' apart in line

Depth 115-120', Charge 7x20lb

PLAYBACK INFORMATION

*Filters:* 1/25-1/78

*AGC* : S

*Gain Initial:* -50

*Final:* -30

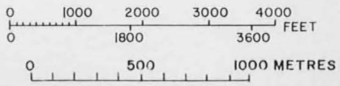
*Trip Delay:* 0

*Compositing:* Nil

VELOCITY INFORMATION

t·Δt, Expanded spread at SP114
Traverse A

HORIZONTAL SCALE




## TRAVERSE B

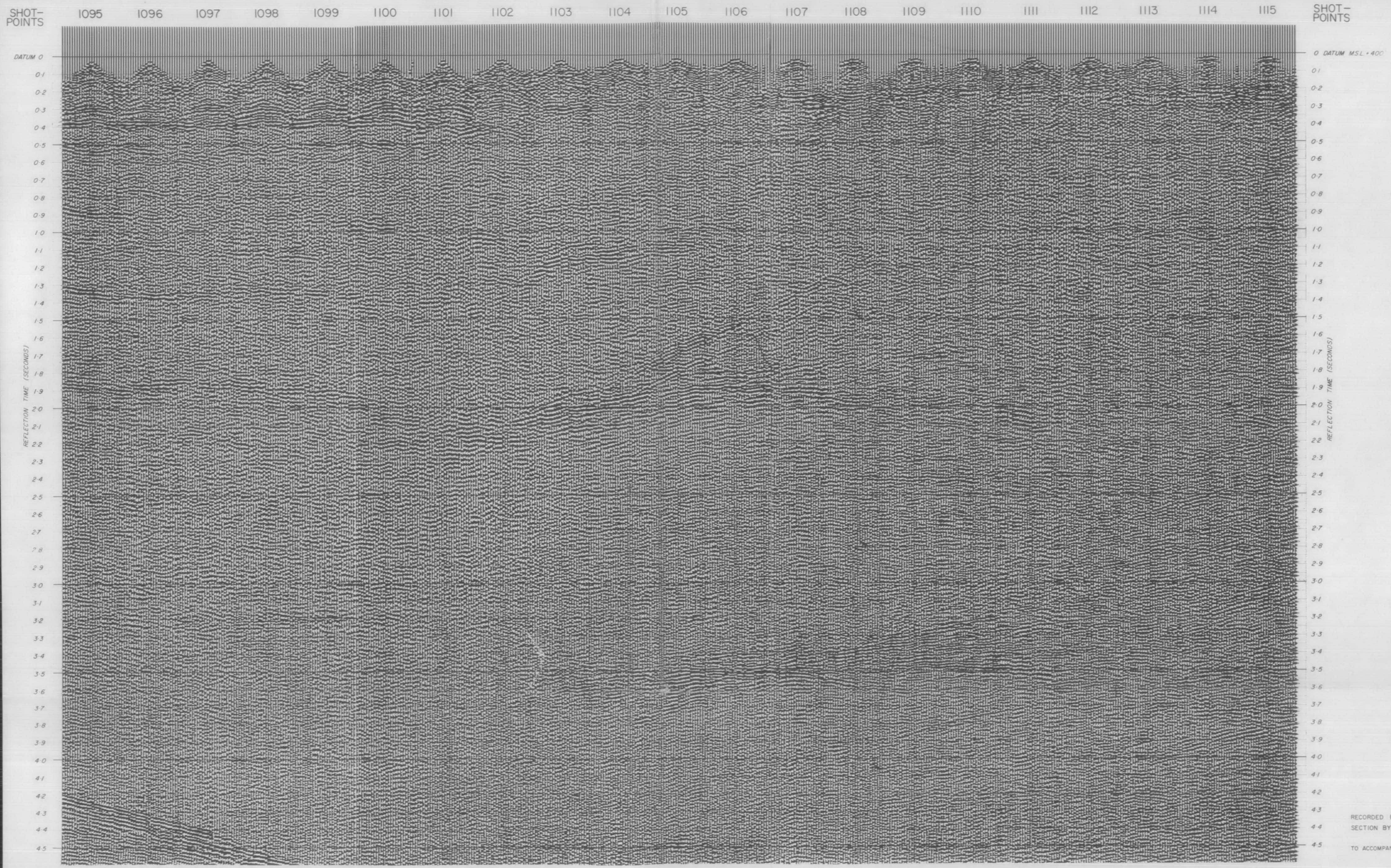
RECORDED BY: *Seismic Party No. 1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS42*

TO ACCOMPANY RECORD No. 1970/52

F54/B3-191

PLATE 9




# CORRECTED RECORD SECTION

## RECORDING INFORMATION

*Magnetic Recorder*: PMR-20

*Amplifiers* : 7000B

*Prefilters*: 18c/s, 24 dB/octave (SP1095-SP1100)
18c/s, 12 dB/octave (SP1101-SP1115)

*Filters* : 0-K120

*AGC* : Med. (SP1095-SP1100) W.B.(SP1101-SP1115)

*Gain Initial*: -65 to -75

*Final*: -10

*Geophones*: HSJ-14c/s

*Geophone Station Interval* : 150'

*Geophone Pattern*:

SP1095-SP1100, 16/trace, 10' apart in line

SP1101-SP1115, 16/trace, 20' apart in line

*Shot Hole Pattern*

SP1095-SP1100, 5 holes, 32' apart in line

Depth 96-100', Charge 5 x 15lb

SP1101-SP1115, 5 or 7 holes, 50' apart in line

Depth 108-120', Charge 5 x 30lb

## PLAYBACK INFORMATION

*Filters*: 2/31-1/78

*AGC*: S

*Gain Initial*: -40

*Final*: -20

*Trip Delay*: 0-0·1s

*Compositing*: Nil

## VELOCITY INFORMATION

t-Δt

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET

0 1800 3600

0 500 1000 METRES

# TRAVERSE D

RECORDED BY: *Seismic Party No. 1*

SECTION BY: *Bureau of Mineral Resources*
*Playback Centre SIE MS42*

TO ACCOMPANY RECORD No. 1970/52

F54/B3-192


PLATE 10

# CORRECTED RECORD SECTION

## RECORDING INFORMATION

*Magnetic Recorder* PMR-20

*Amplifiers*: 7000B

*Prefilters*: 18c/s, 12dB/octave (SP1132-SP1165)
18c/s, 24dB/octave (SP1166-SP1200)

*Filters*: 0-K120

*AGC*: W.B.(SP1132-SP1165), Med. (SP1166-SP1200)

*Gain Initial*: -65 to -80

*Final*: -10

*Geophones*: HSJ-14c/s

*Geophone Station Interval*: 150'

*Geophone Pattern*:

32/trace in 2 rows of 16 in line
Rows 30' apart, Geophones 10' apart

*Shot Hole Pattern*:

SP1132-SP1180, 5 holes, 50' apart in line
Depth 80-85', Charge 5 x 15-20lb
SP1181-SP1200, 3 holes, 50' apart in line
Depth 87-100', Charge 3 x 30-50lb

## PLAYBACK INFORMATION

*Filters*: 2/31-1/78

*AGC*: S

*Gain Initial*: -40

*Final*: -20

*Trip Delay*: 0

*Compositing*: Nil

## VELOCITY INFORMATION

t:Δt

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1800 3600

0 500 1000 METRES

# TRAVERSE D

RECORDED BY Seismic Party No 1
SECTION BY Bureau of Mineral Resources
Playback Centre S/E MS42
TO ACCOMPANY RECORD No 1970/52

F54/B3-193

# CORRECTED RECORD SECTION

PLATE II


RECORDING INFORMATION

*Magnetic Recorder*: PMR-20

*Amplifiers*: 7000B

*Prefilters*: 18c/s, 24dB/octave

*Filters*: 0-K120

*AGC*: Med.

*Gain Initial*: -65 to -80

*Final*: -10

*Geophones*: HSJ-14c/s

*Geophone Station Interval*: 150'

*Geophone Pattern*:

32/trace in 2 rows of 16 in line
Rows 30' apart, Geophones 10' apart

*Shot Hole Pattern*:

3 holes, 50' apart in line
Depth 87-100', Charge 3 x 30-50lb

PLAYBACK INFORMATION

*Filters*: 2/31-1/78

*AGC*: S

*Gain Initial*: -40

*Final*: -20

*Trip Delay*: 0

*Compositing*: Nil

VELOCITY INFORMATION

$t \cdot \Delta t$

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1800 3600

0 500 1000 METRES

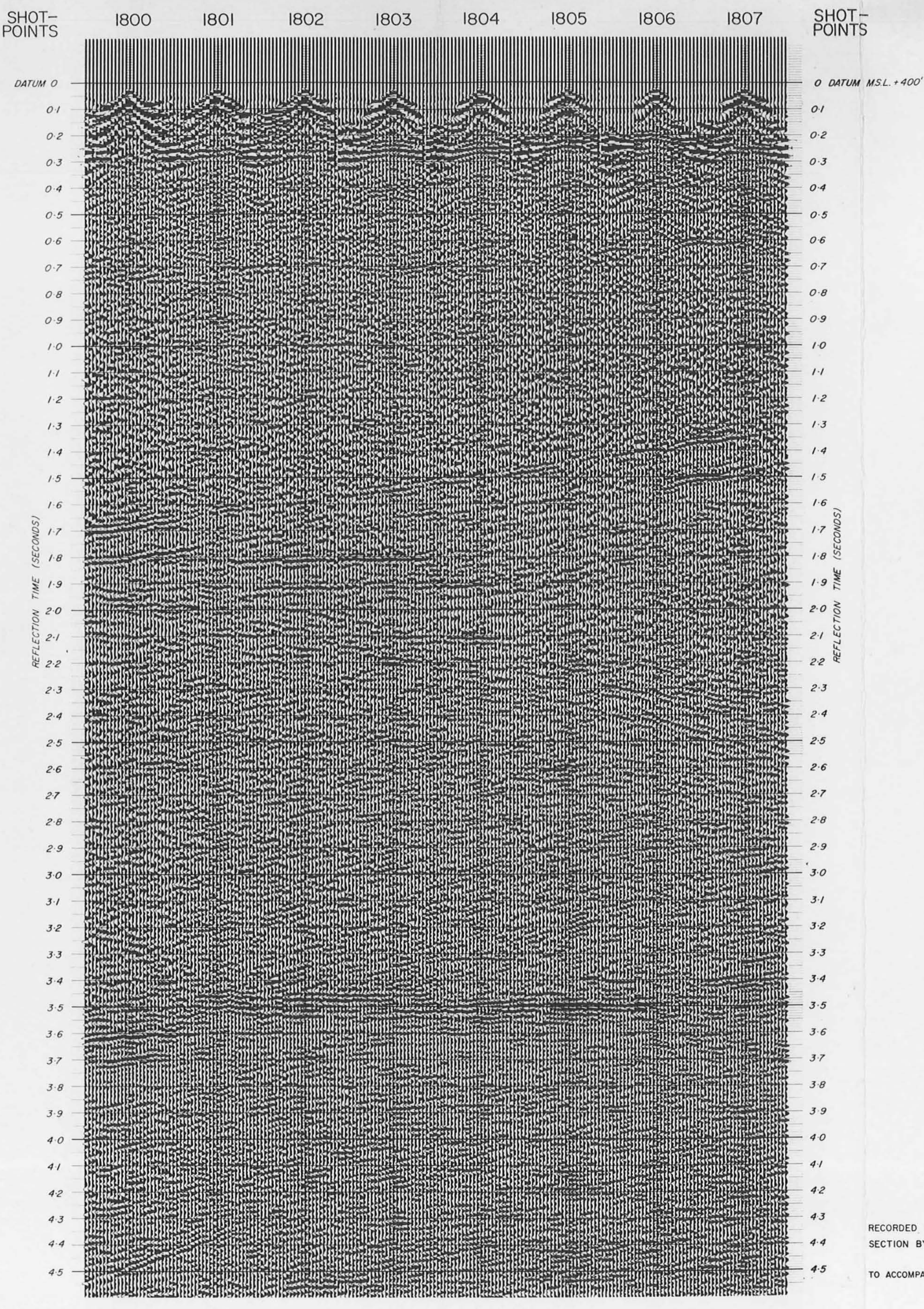
TRAVERSE D

RECORDED BY *Seismic Party No 1*
SECTION BY *Bureau of Mineral Resources Playback Centre SIE MS42*
TO ACCOMPANY RECORD No 1970/52

F54/B3-194

PLATE 12

# CORRECTED RECORD SECTION




## RECORDING INFORMATION

*Magnetic Recorder*: PMR-20
*Amplifiers* : 7000B
*Prefilters*: 18c/s, 24dB/octave
*Filters* : 0-K120
*AGC* : Med.
*Gain Initial*: -60 to -80
*Final*: -10
*Geophones*: HSJ-14c/s
*Geophone Station Interval*: 150'
*Geophone Pattern*:

16/trace, 10' apart in line

*Shot Hole Pattern*:

5 holes, 32' apart in line
Depth 94-100', Charge 5 x 20lb

## PLAYBACK INFORMATION

*Filters*: 1/25-1/78
*AGC* : M
*Gain Initial*: -60
*Final*: -30
*Trip Delay*: 0·1s
*Compositing*: Nil

## VELOCITY INFORMATION

t:Δt

## HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1800 3600
0 500 1000 METRES

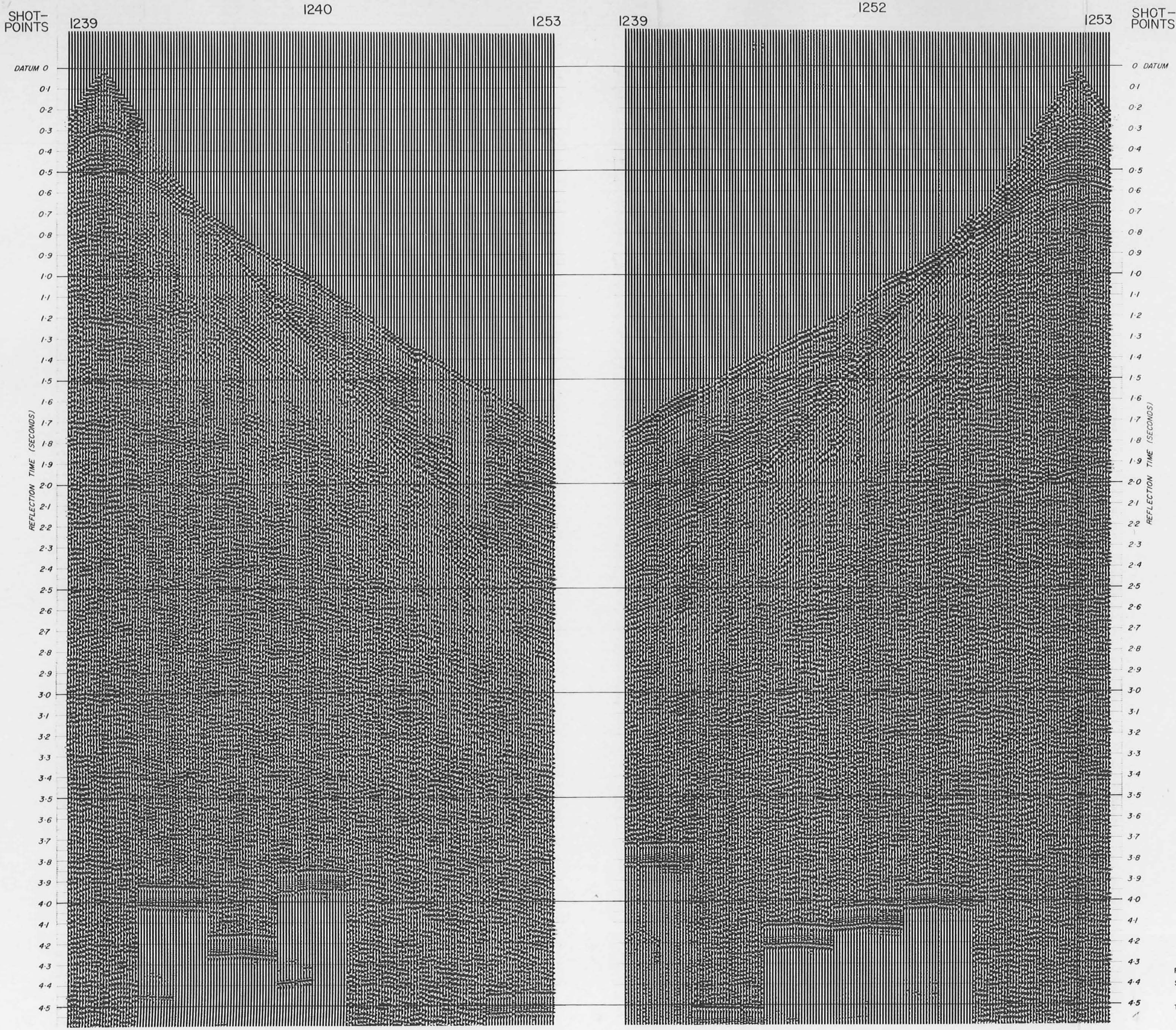
# TRAVERSE E

RECORDED BY: *Seismic Party No. 1*
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS42*
TO ACCOMPANY RECORD No. 1970/52

F54/B3-195

PLATE 13

# RECORD SECTION




## RECORDING INFORMATION

*Magnetic Recorder*: PMR-20

*Amplifiers* : 7000B

*Prefilters*: 18c/s, 24dB/octave

*Filters* : 0-K120

*AGC* : Med.

*Gain Initial*: -55

*Final*: -10

*Geophones*: HSJ-14c/s

*Geophone Station Interval* : 150'

*Geophone Pattern* :

32/trace in 2 rows of 16 in line
Rows 30' apart, Geophones 10' apart

*Shot Hole Pattern*:

3 holes, 50' apart in line
Depth 88-100', Charge 3x30lb to 3x200lb

## PLAYBACK INFORMATION

*Filters*: 2/31-1/78

*AGC* : S

*Gain Initial*: -60 to -40

*Final*: -20

*Trip Delay*: Varied

*Compositing*: Nil

## VELOCITY INFORMATION

Nil

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1800 3600

0 500 1000 METRES

# OFFSET REFLECTION/REFRACTION TRAVERSE D, SP1240 & SP1252

RECORDED BY: *Seismic Party No. 1*
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS42*
TO ACCOMPANY RECORD No. 1970/52

F54/B3-198

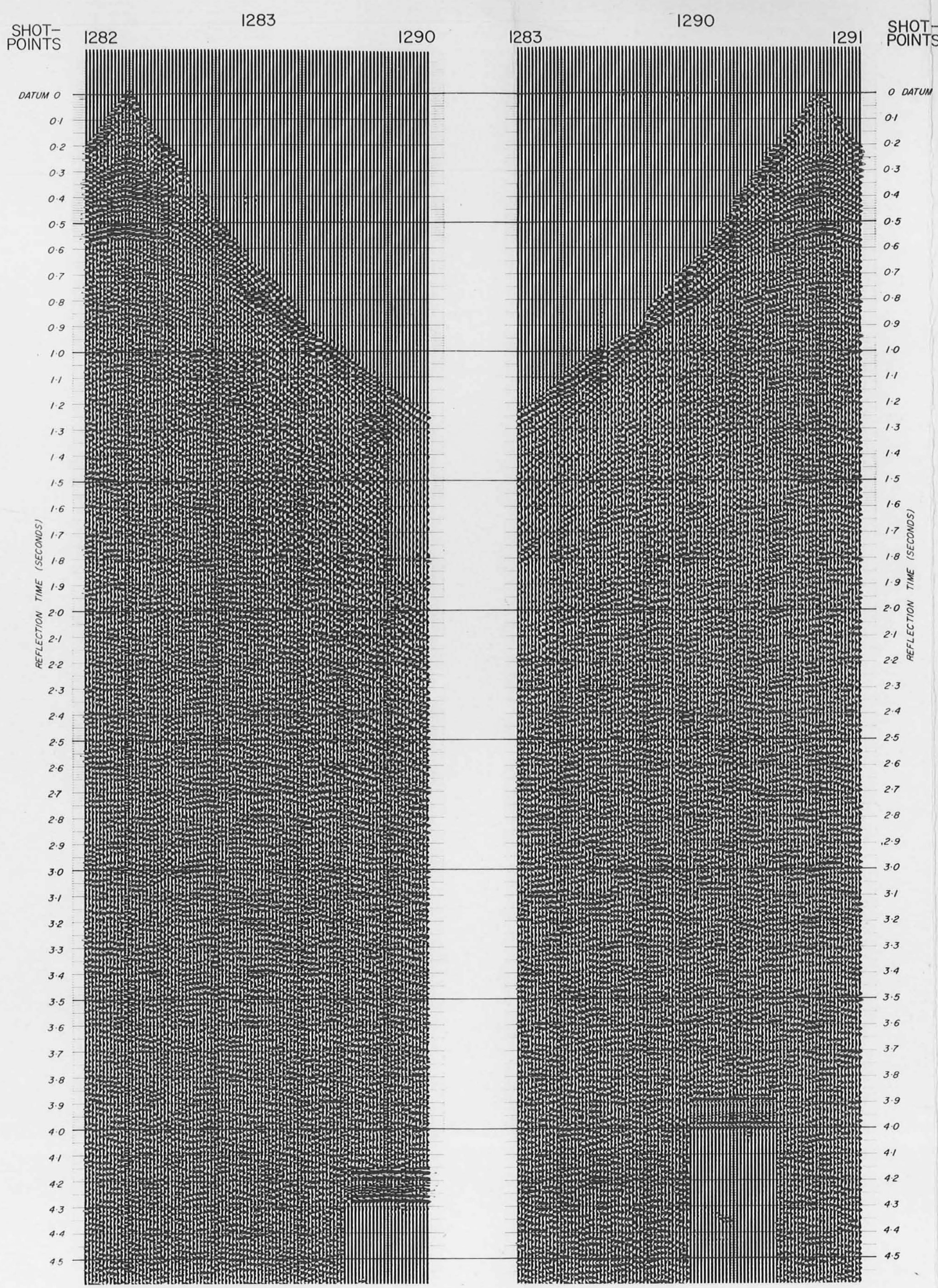



PLATE 14

# RECORD SECTION

## RECORDING INFORMATION

*Magnetic Recorder*: PMR-20
*Amplifiers* : 7000B
*Prefilters*: 18c/s, 24dB/octave
*Filters* : 0-K120
*AGC* : Med.
*Gain Initial*: -55
*Final*: -10
*Geophones*: HSJ-14c/s
*Geophone Station Interval* : 150'
*Geophone Pattern* :

32/trace in 2 rows of 16 in line
Rows 30' apart, Geophones 10' apart

*Shot Hole Pattern*:

3 holes, 50' apart in line
Depth 88-100', Charge 3x30lb to 3x200lb

## PLAYBACK INFORMATION

*Filters*: 2/31-1/78
*AGC* : S
*Gain Initial*: -60 to -40
*Final*: -20
*Trip Delay*: Varied
*Compositing*: Nil

## VELOCITY INFORMATION

Nil

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1800 3600

0 500 1000 METRES

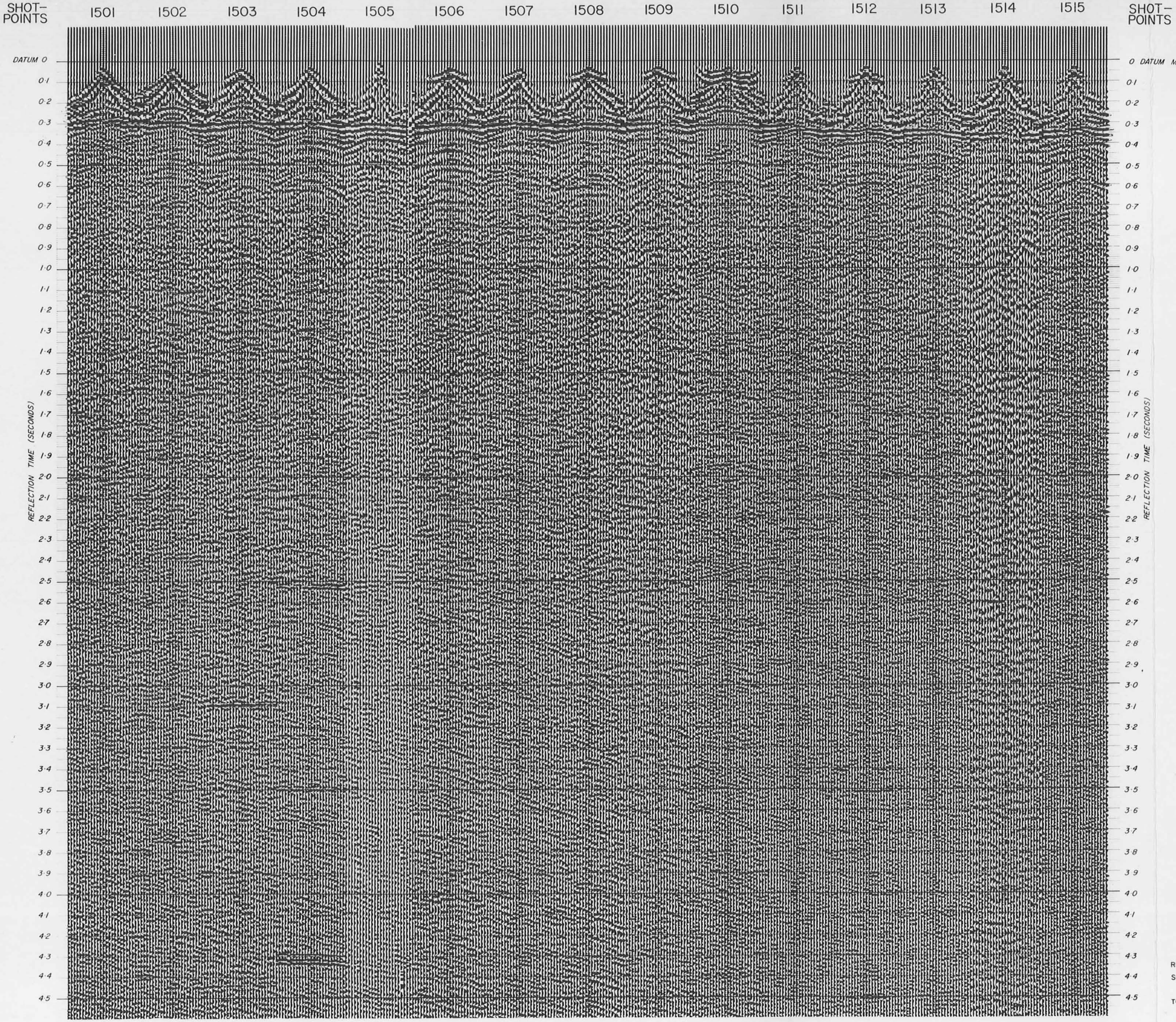
# OFFSET REFLECTION/REFRACTION TRAVERSE D, SP1283 & SP1290

RECORDED BY: *Seismic Party No. 1*
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS42*
TO ACCOMPANY RECORD No. 1970/52

F54/B3-199

PLATE 15

# CORRECTED RECORD SECTION




RECORDING INFORMATION

*Magnetic Recorder:* PMR-20

*Amplifiers* : 7000B

*Prefilters:* 18c/s, 24dB/octave

*Filters* : 0-K120

*AGC* : Med.

*Gain Initial:* -50 to -65

*Final:* -10

*Geophones:* HSJ-14c/s

*Geophone Station Interval:* 150'

*Geophone Pattern:*

32/trace in 2 rows of 16 in line
Rows 30' apart, Geophones 10' apart

*Shot Hole Pattern:*

3 holes, 50' apart in line
Depth 88-100', Charge 3 x 50lb

PLAYBACK INFORMATION

*Filters:* 1/25-1/78

*AGC* : Med.

*Gain Initial:* -60

*Final:* -30

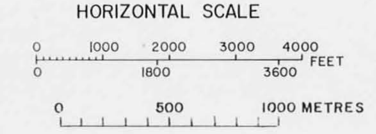
*Trip Delay:* 0·1s

*Compositing:* Nil

VELOCITY INFORMATION

t:Δt

HORIZONTAL SCALE

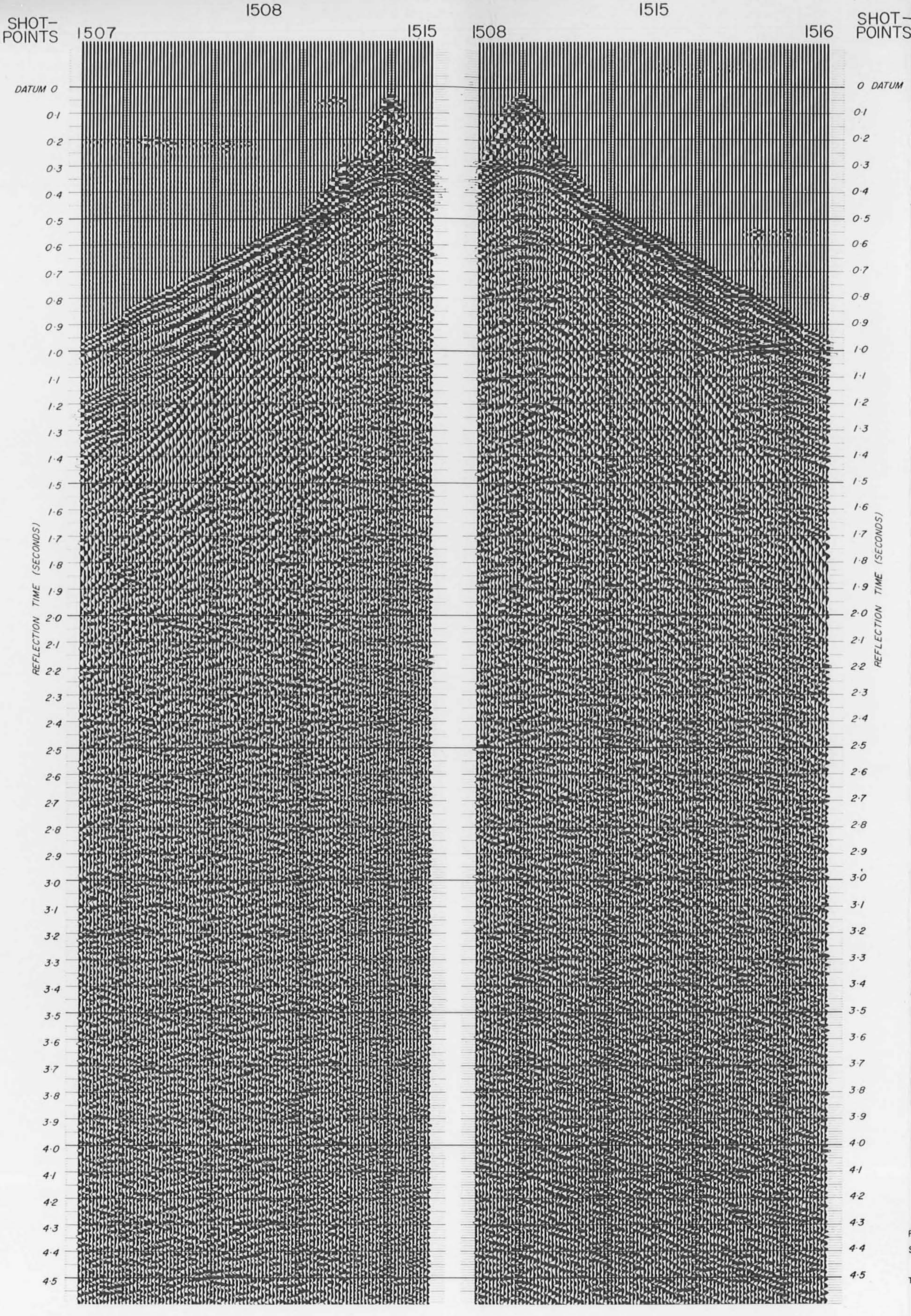



## TRAVERSE F

RECORDED BY: *Seismic Party No. 1*
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS42*
TO ACCOMPANY RECORD No. 1970/52

F54/B3-196

# RECORD SECTION




## RECORDING INFORMATION

*Magnetic Recorder*: PMR-20
*Amplifiers* : 7000B
*Prefilters*: 18c/s, 24dB/octave
*Filters* : 0-K120
*AGC* : Med.
*Gain Initial*: -55
*Final*: -10
*Geophones*: HSJ-14c/s
*Geophone Station Interval* : 150'
*Geophone Pattern* :

32/trace in 2 rows of 16 in line
Rows 30' apart, Geophones 10' apart

*Shot Hole Pattern*:

3 holes, 50' apart in line
Depth 88-100', Charge 3x30lb to 3x300lb

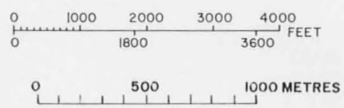
## PLAYBACK INFORMATION

*Filters*: 1/25-1/78
*AGC* : Med.
*Gain Initial*: -60
*Final*: -30
*Trip Delay* : Varied
*Compositing*: Nil

## VELOCITY INFORMATION

Nil

HORIZONTAL SCALE



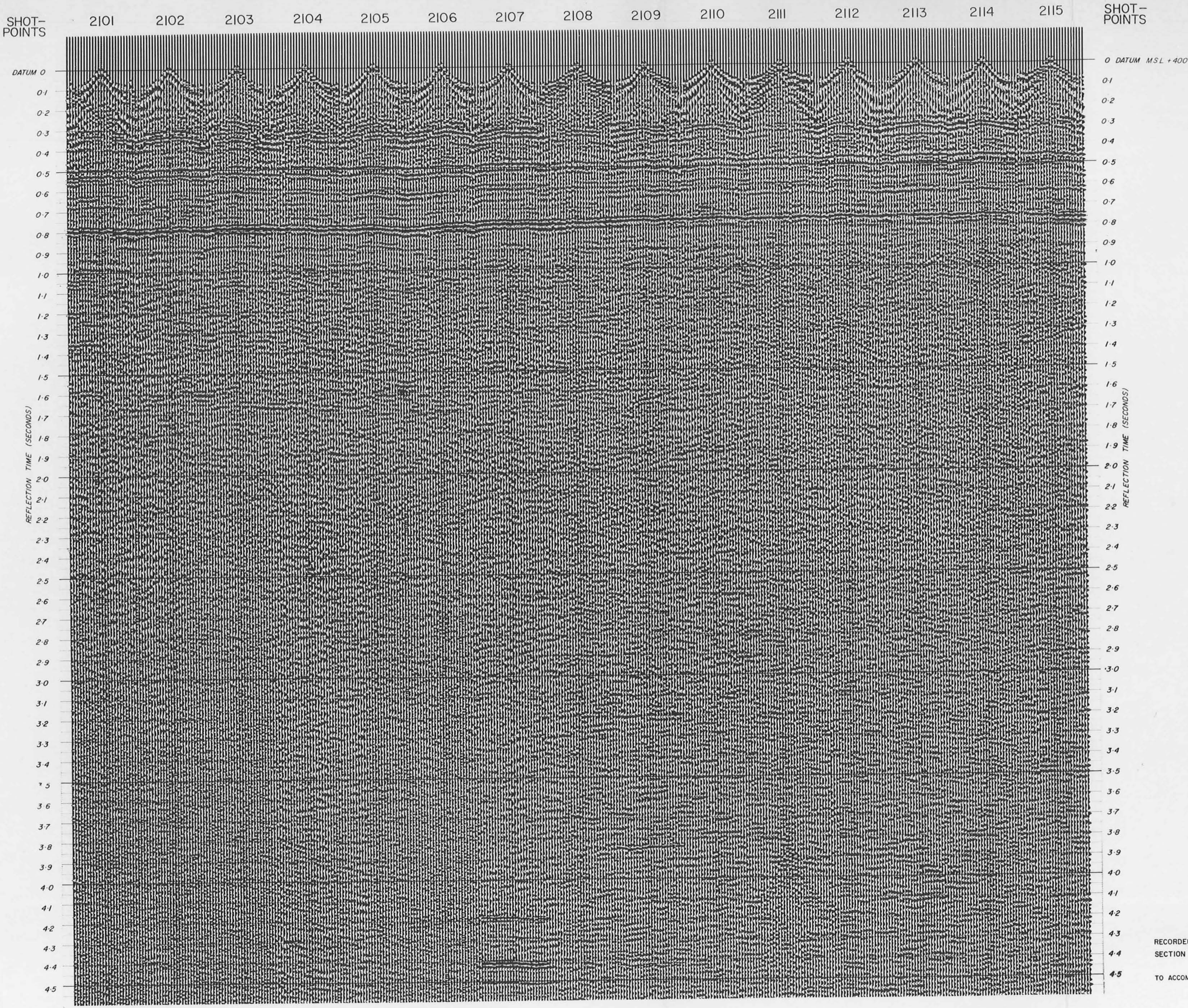

# OFFSET REFLECTION/REFRACTION TRAVERSE F, SP1508 & SP1515

RECORDED BY: *Seismic Party No. 1*
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS42*
TO ACCOMPANY RECORD No. 1970/52

F54/B3-200

PLATE 17

# CORRECTED RECORD SECTION




RECORDING INFORMATION

*Magnetic Recorder*: PMR-20
*Amplifiers* : 7000B
*Prefilters*: 18c/s, 24dB/octave
*Filters* : 0-K120
*AGC* : Med.
*Gain Initial*: -50 to -65
*Final*: -10
*Geophones*: HSJ-14c/s
*Geophone Station Interval*: 150'
*Geophone Pattern*:
16/trace, 10' apart in line

*Shot Hole Pattern*:
3 holes, 50' apart in line
Depth 91-100', Charge 3 x 30lb

PLAYBACK INFORMATION

*Filters*: 1/25-1/78
*AGC* : Med.
*Gain Initial*: -50
*Final*: -20
*Trip Delay*: 0
*Compositing*: Nil

VELOCITY INFORMATION

t:Δt

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1800 3600

0 500 1000 METRES

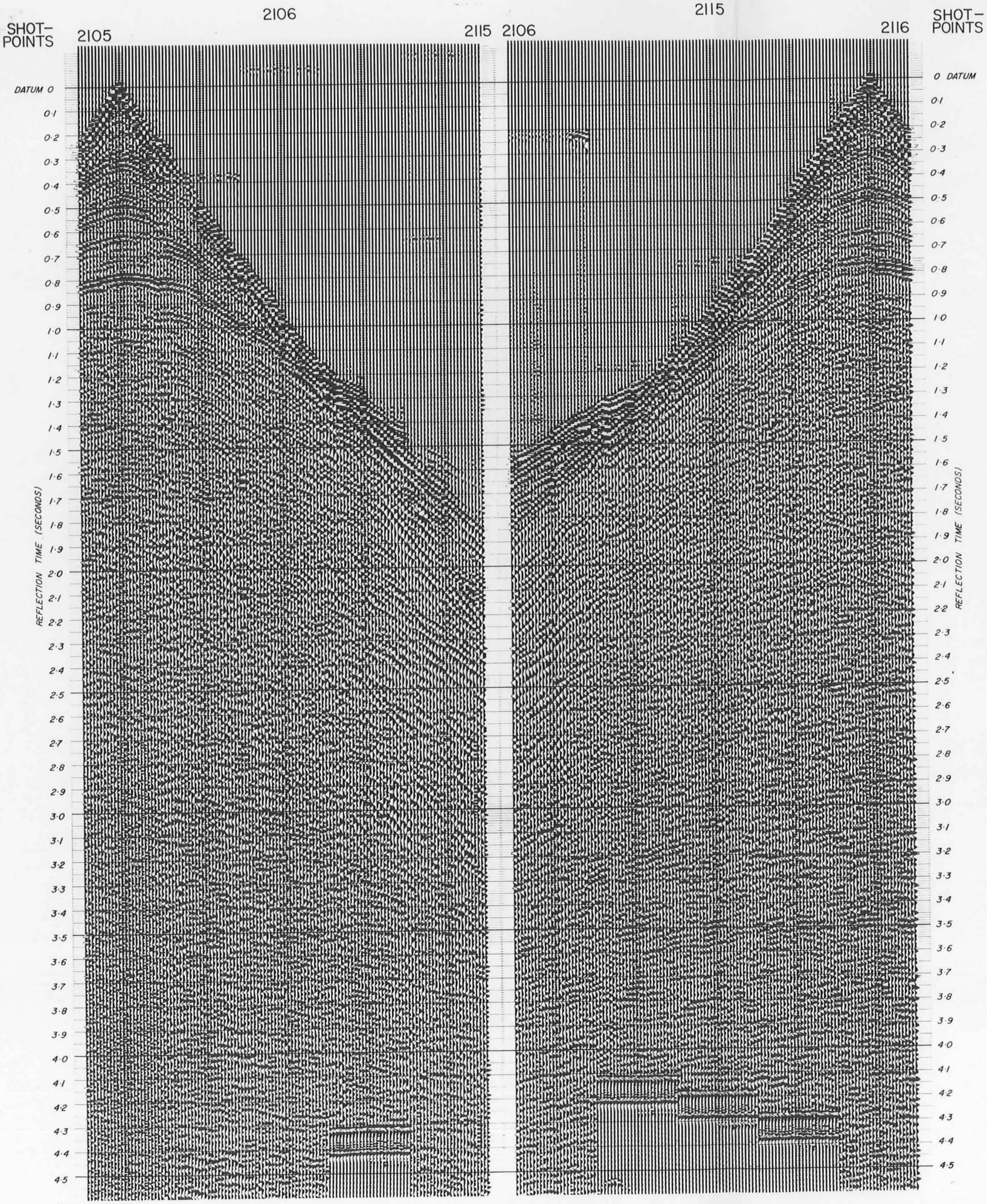
TRAVERSE G

RECORDED BY: *Seismic Party No. 1*
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS42*
TO ACCOMPANY RECORD No. 1970/52

F54/B3-197

PLATE 18

# RECORD SECTION




RECORDING INFORMATION

*Magnetic Recorder:* PMR-20
*Amplifiers* : 7000B
*Prefilters:* 18c/s, 24dB/octave
*Filters* : 0-K120
*AGC* : Med.
*Gain Initial:* -50 to -65
*Final:* -10
*Geophones:* HSJ-14c/s
*Geophone Station Interval:* 150'
*Geophone Pattern:*

16/trace, 10' apart in line

*Shot Hole Pattern:*

3 holes, 50' apart in line
Depth 91-100', Charge 3x30lb to 3x60lb

PLAYBACK INFORMATION

*Filters:* 1/25-1/78
*AGC* : Med.
*Gain Initial:* -60
*Final:* -30
*Trip Delay:* Varied
*Compositing:* Nil

VELOCITY INFORMATION

Nil

HORIZONTAL SCALE

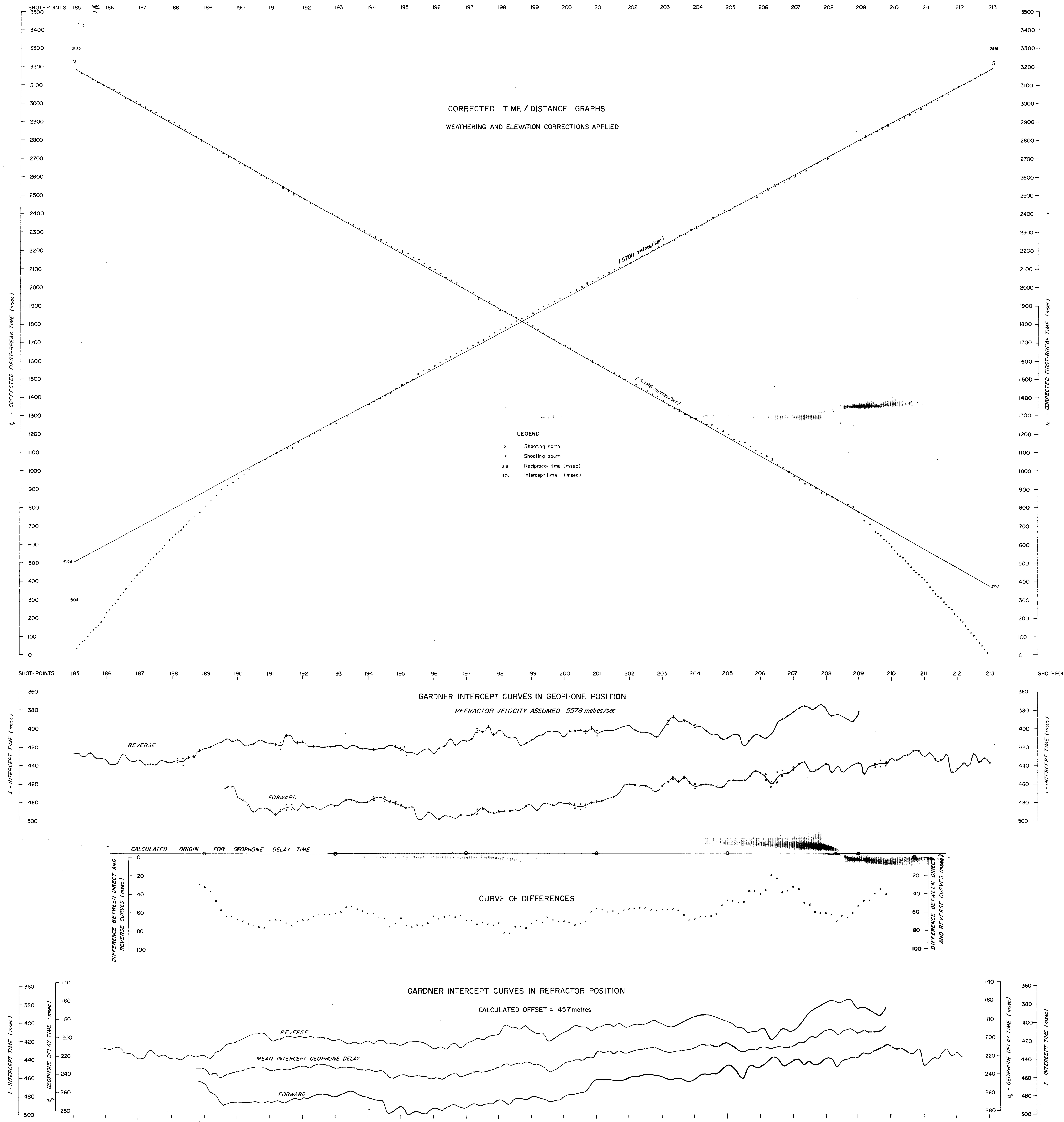
0 1000 2000 3000 4000 FEET
0 1800 3600
0 1000 METRES

OFFSET REFLECTION/REFRACTION
TRAVERSE G, SP2106 & SP2115

RECORDED BY: *Seismic Party No. 1*
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS42*
TO ACCOMPANY RECORD No. 1970/52

F54/B3-201

PLATE 19




HORIZONTAL SCALE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1000 0 1000 METRES

FLINDERS RIVER SEISMIC SURVEY, QUEENSLAND, 1966

TRAVERSE A, RICHMOND

REFRACTION PROBE SHOT-POINTS 185-213

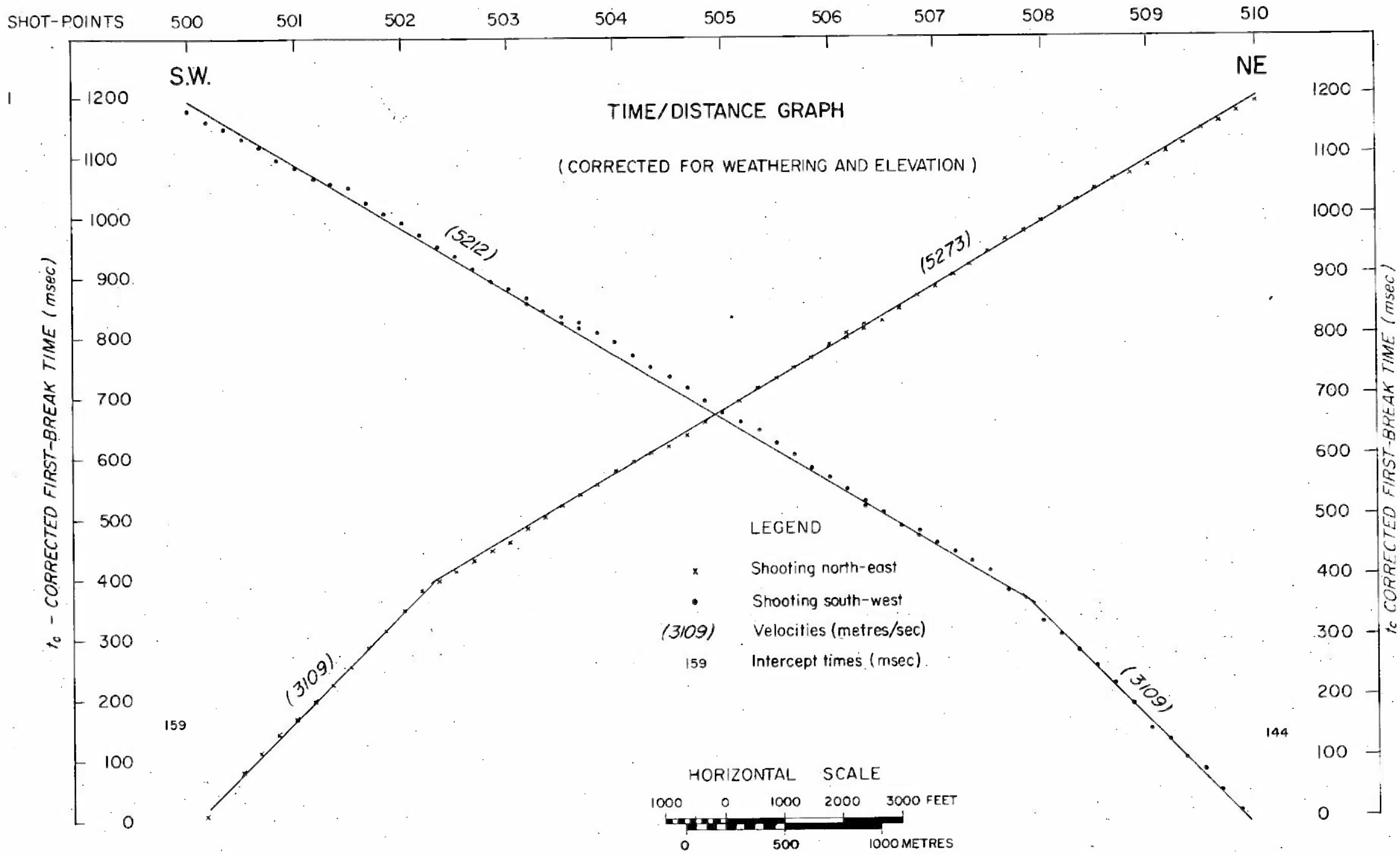
TO ACCOMPANY RECORD No. 1970/52

*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics*

F54/B3-207

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

TO ACCOMPANY RECORD No. 1970/52




FLINDERS RIVER SEISMIC SURVEY, QUEENSLAND 1966

TRAVERSE C, RICHMOND

REFRACTION PROBE

F54/B3-188

PLATE 20

PLATE 21


HORIZONTAL SCALE

2000 0 2000 4000 6000 8000 FEET

1000 500 0 1000 METRES

**FLINDERS RIVER SEISMIC SURVEY, QUEENSLAND, 1966**

**TRAVERSE D, JULIA CREEK**

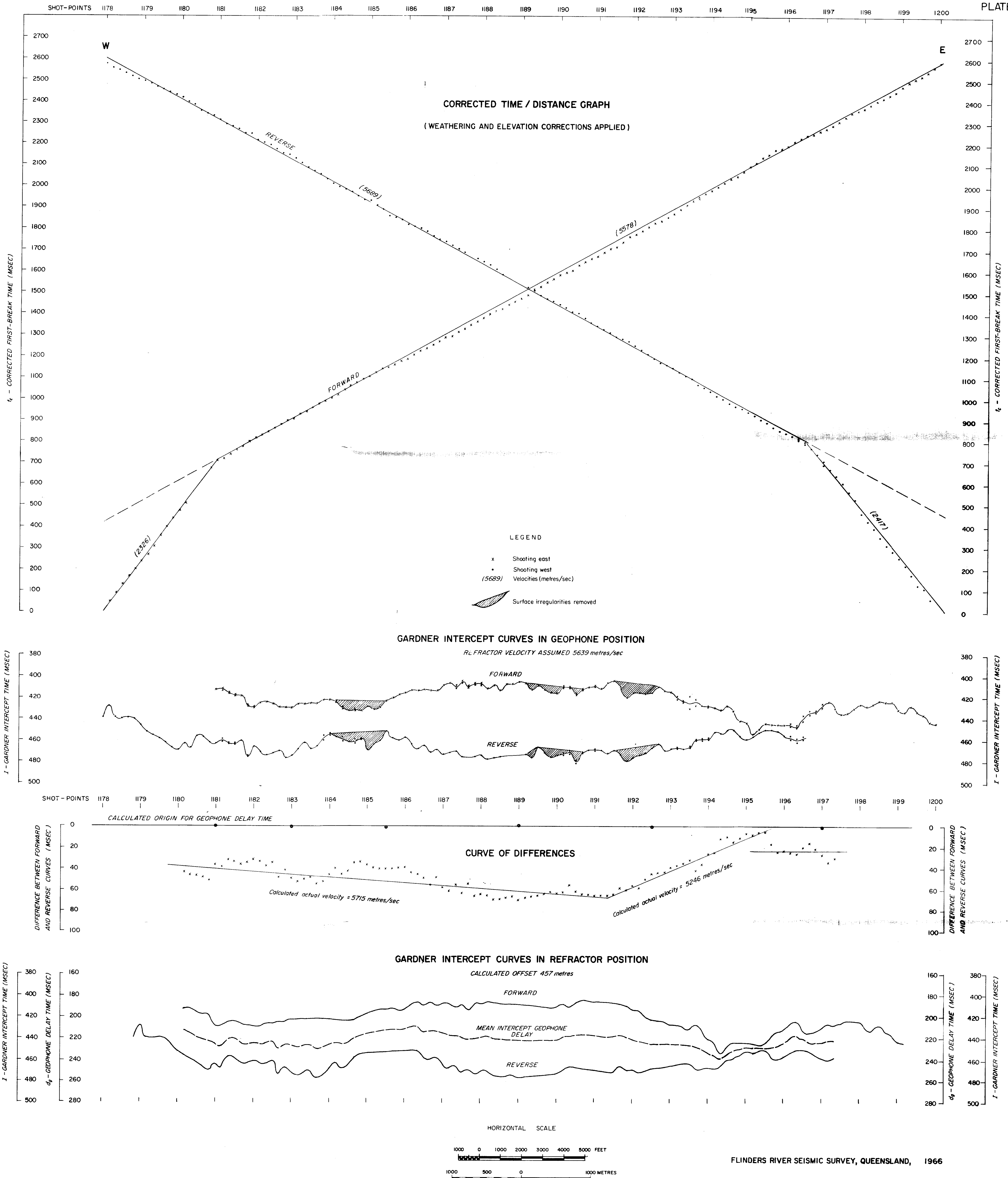
**REFRACTION PROFILE, SHOT-POINTS 1112-1147**

TO ACCOMPANY RECORD No. 1970/52

*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics*

F54/B3-187

PLATE 22




FLINDERS RIVER SEISMIC SURVEY, QUEENSLAND, 1966

TRAVERSE D, JULIA CREEK

REFRACTION PROFILE, SHOT-POINTS 1178-1200

TO ACCOMPANY RECORD No. 1970/52

*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics*

F54/B3-205

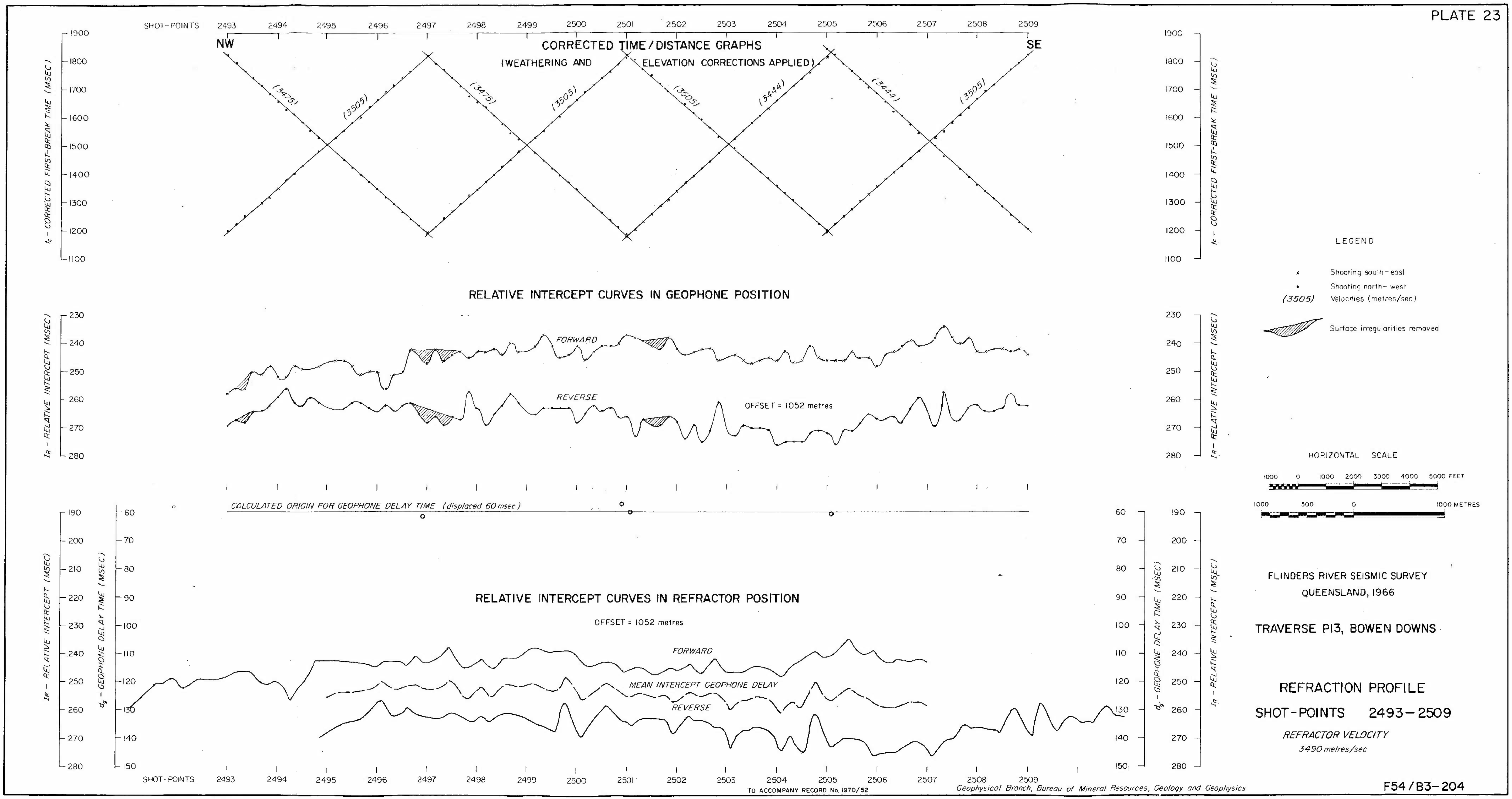


PLATE 23
SHOT-POINTS
NW
SE
CORRECTED TIME/DISTANCE GRAPHS
(WEATHERING AND ELEVATION CORRECTIONS APPLIED)
(3475)
(3505)
(3444)
$t_c$ - CORRECTED FIRST-BREAK TIME (MSEC)
RELATIVE INTERCEPT CURVES IN GEOPHONE POSITION
FORWARD
REVERSE
OFFSET = 1052 metres
$I_R$ - RELATIVE INTERCEPT (MSEC)
CALCULATED ORIGIN FOR GEOPHONE DELAY TIME (displaced 60 msec)
RELATIVE INTERCEPT CURVES IN REFRACTOR POSITION
OFFSET = 1052 metres
FORWARD
MEAN INTERCEPT GEOPHONE DELAY
REVERSE
$d_g$ - GEOPHONE DELAY TIME (MSEC)
LEGEND
Shooting south-east
Shooting north-west
(3505) Velocities (metres/sec)
Surface irregularities removed
HORIZONTAL SCALE
1000 0 1000 2000 3000 4000 5000 FEET
1000 500 0 1000 METRES
FLINDERS RIVER SEISMIC SURVEY
QUEENSLAND, 1966
TRAVERSE P13, BOWEN DOWNS
REFRACTION PROFILE
SHOT-POINTS 2493-2509
REFRACTOR VELOCITY
3490 metres/sec
TO ACCOMPANY RECORD No. 1970/52
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics
F54/B3-204

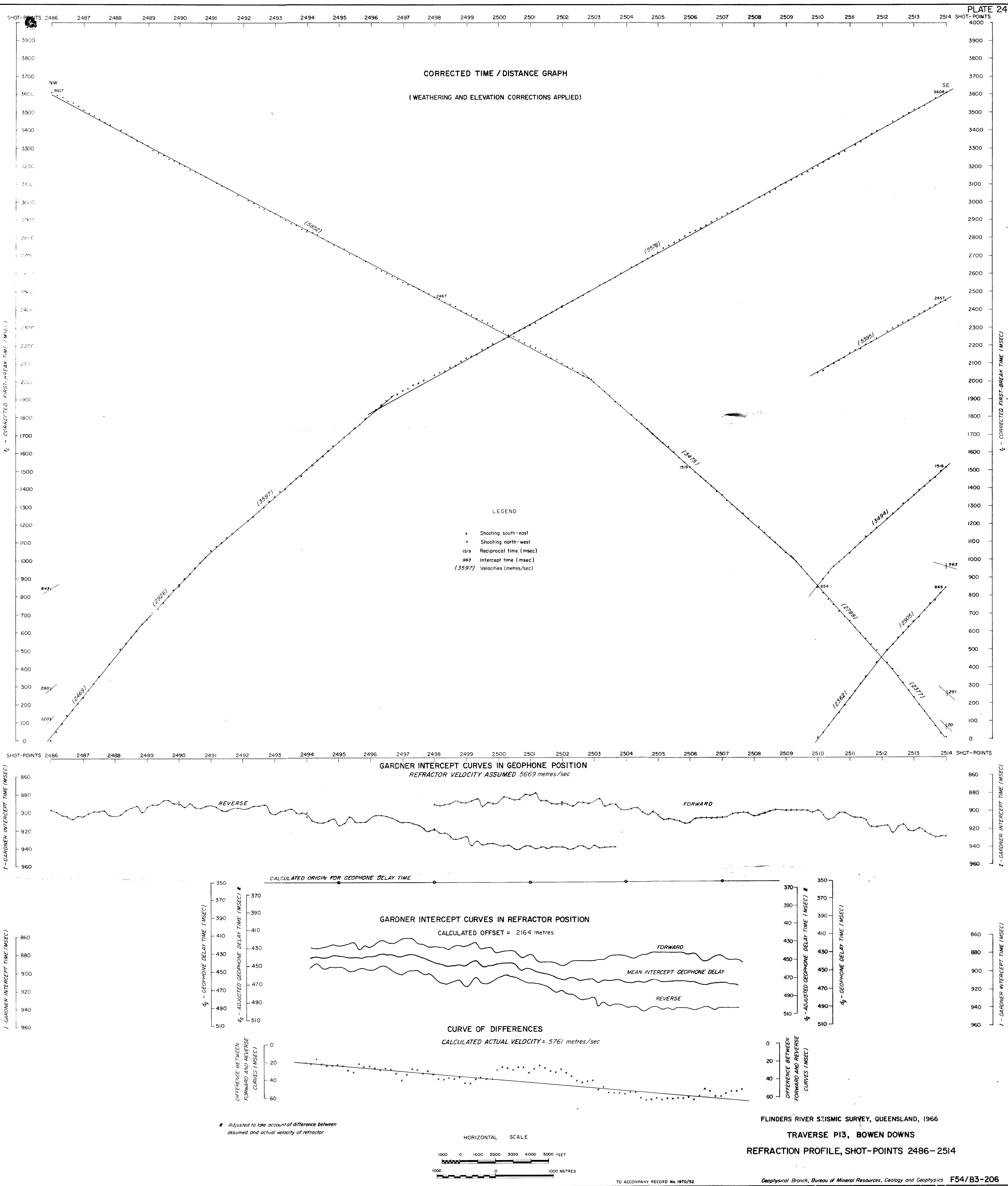
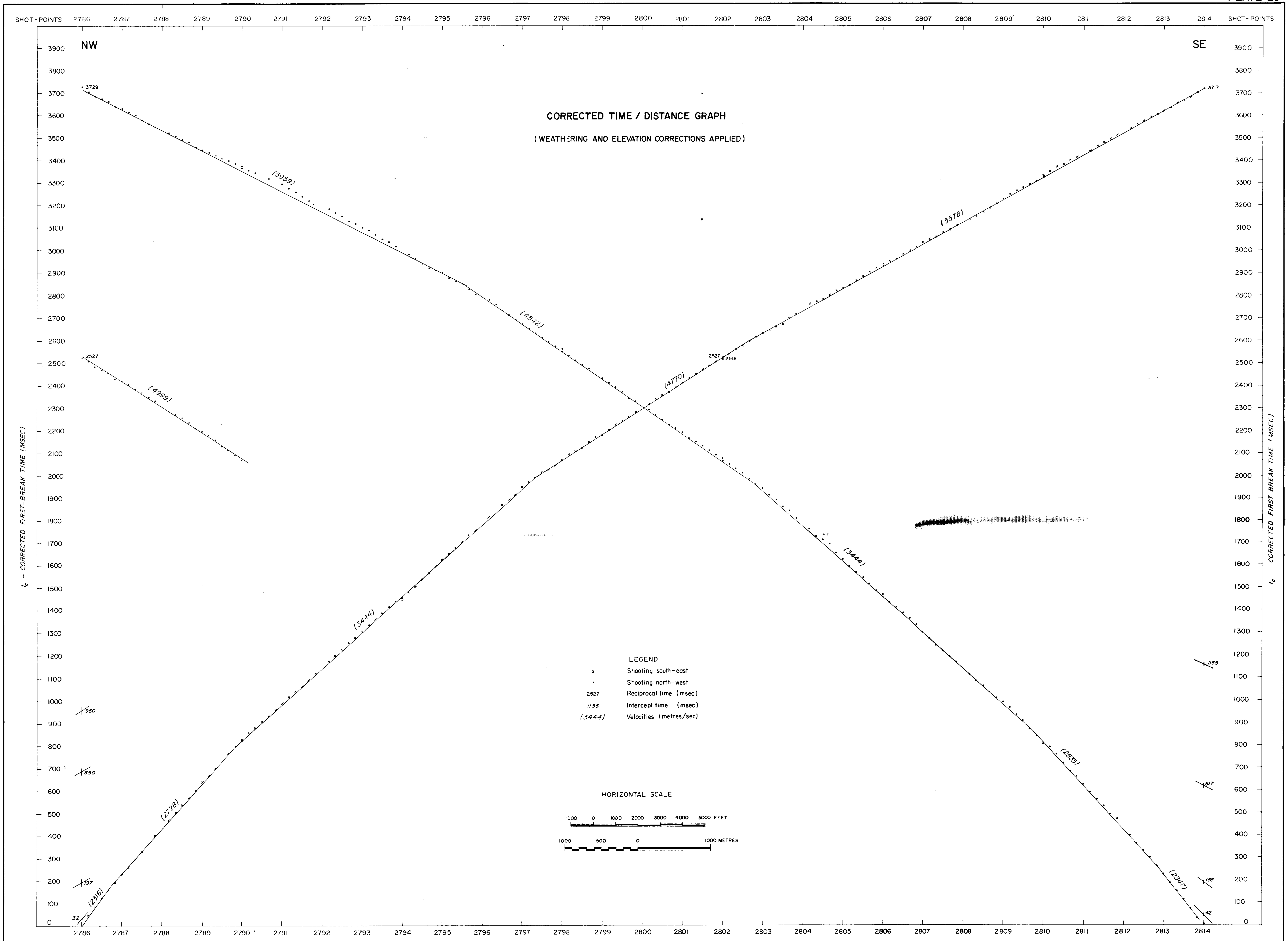


PLATE 24
CORRECTED TIME / DISTANCE GRAPH
(WEATHERING AND ELEVATION CORRECTIONS APPLIED)
NW
SE
SHOT-POINTS
$t_c$ - CORRECTED FIRST-BREAK TIME (MSEC)
(5852)
(5578)
(5395)
(3597)
(3475)
(3494)
(2926)
(2789)
(2905)
(2469)
(2362)
(2377)
LEGEND
x Shooting south-east
• Shooting north-west
1519 Reciprocal time (msec)
963 Intercept time (msec)
(3597) Velocities (metres/sec)
GARDNER INTERCEPT CURVES IN GEOPHONE POSITION
REFRACTOR VELOCITY ASSUMED 5669 metres/sec
REVERSE
FORWARD
I - GARDNER INTERCEPT TIME (MSEC)
CALCULATED ORIGIN FOR GEOPHONE DELAY TIME
GARDNER INTERCEPT CURVES IN REFRACTOR POSITION
CALCULATED OFFSET = 2164 metres
FORWARD
MEAN INTERCEPT GEOPHONE DELAY
REVERSE
$d_g$ - GEOPHONE DELAY TIME (MSEC)
$d_g$ - ADJUSTED GEOPHONE DELAY TIME (MSEC) *
CURVE OF DIFFERENCES
CALCULATED ACTUAL VELOCITY = 5761 metres/sec
DIFFERENCE BETWEEN FORWARD AND REVERSE CURVES (MSEC)
* Adjusted to take account of difference between assumed and actual velocity of refractor
HORIZONTAL SCALE
1000 0 1000 2000 3000 4000 5000 FEET
1000 0 1000 METRES
TO ACCOMPANY RECORD No. 1970/52
FLINDERS RIVER SEISMIC SURVEY, QUEENSLAND, 1966
TRAVERSE P13, BOWEN DOWNS
REFRACTION PROFILE, SHOT-POINTS 2486-2514
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F54/B3-206



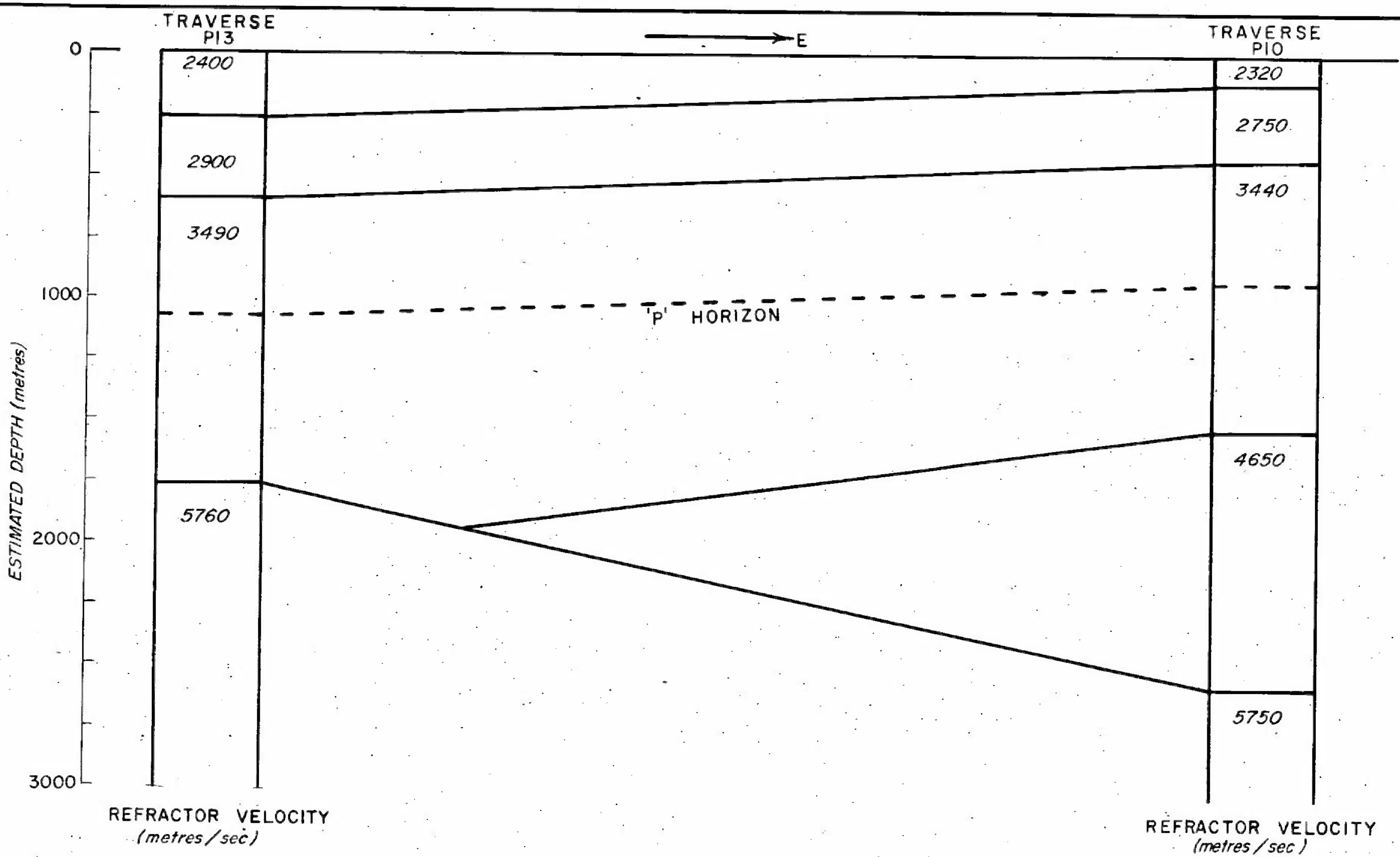

FLINDERS RIVER SEISMIC SURVEY, QUEENSLAND, 1966

TRAVERSE P10, BOWEN DOWNS

REFRACTION PROBE, SHOT-POINTS 2786-2814

TO ACCOMPANY RECORD No. 1970/52 *Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics*

F54/B3-189




DIAGRAMMATIC CROSS-SECTION THROUGH TRAVERSES P10 AND P13

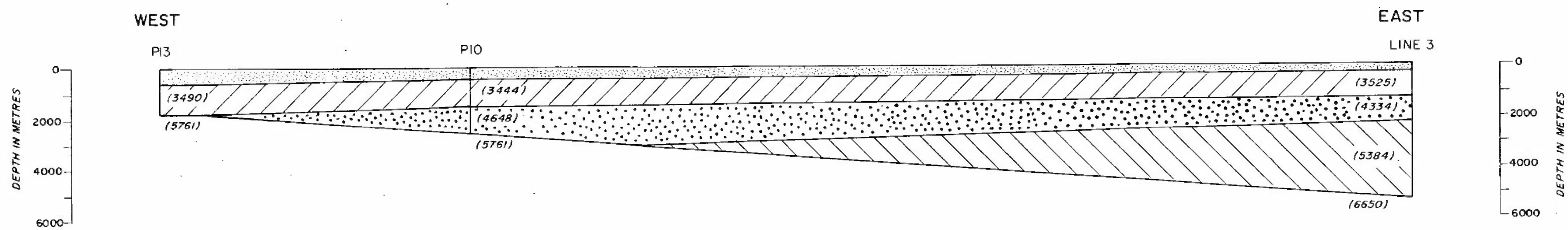
SHOWING CORRELATION OF REFRACTORS

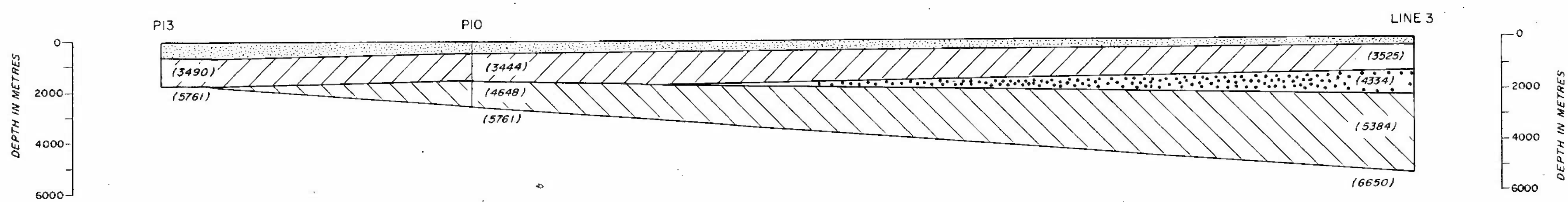
PLATE 26

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

TO ACCOMPANY RECORD No. 1970/52

F54/B3-171-1




HORIZONTAL SCALE

5 0 5 10 15 MILES

10 0 10 20 KILOMETRES

(3490) *REFRACTION VELOCITY (metres/sec)*

# POSSIBLE CORRELATION OF REFRACTORS BETWEEN TRAVERSES P10 and P13 AND LAKE GALILEE

TO ACCOMPANY RECORD No. 1970/52

*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics* F54 / B3-185

PLATE 28

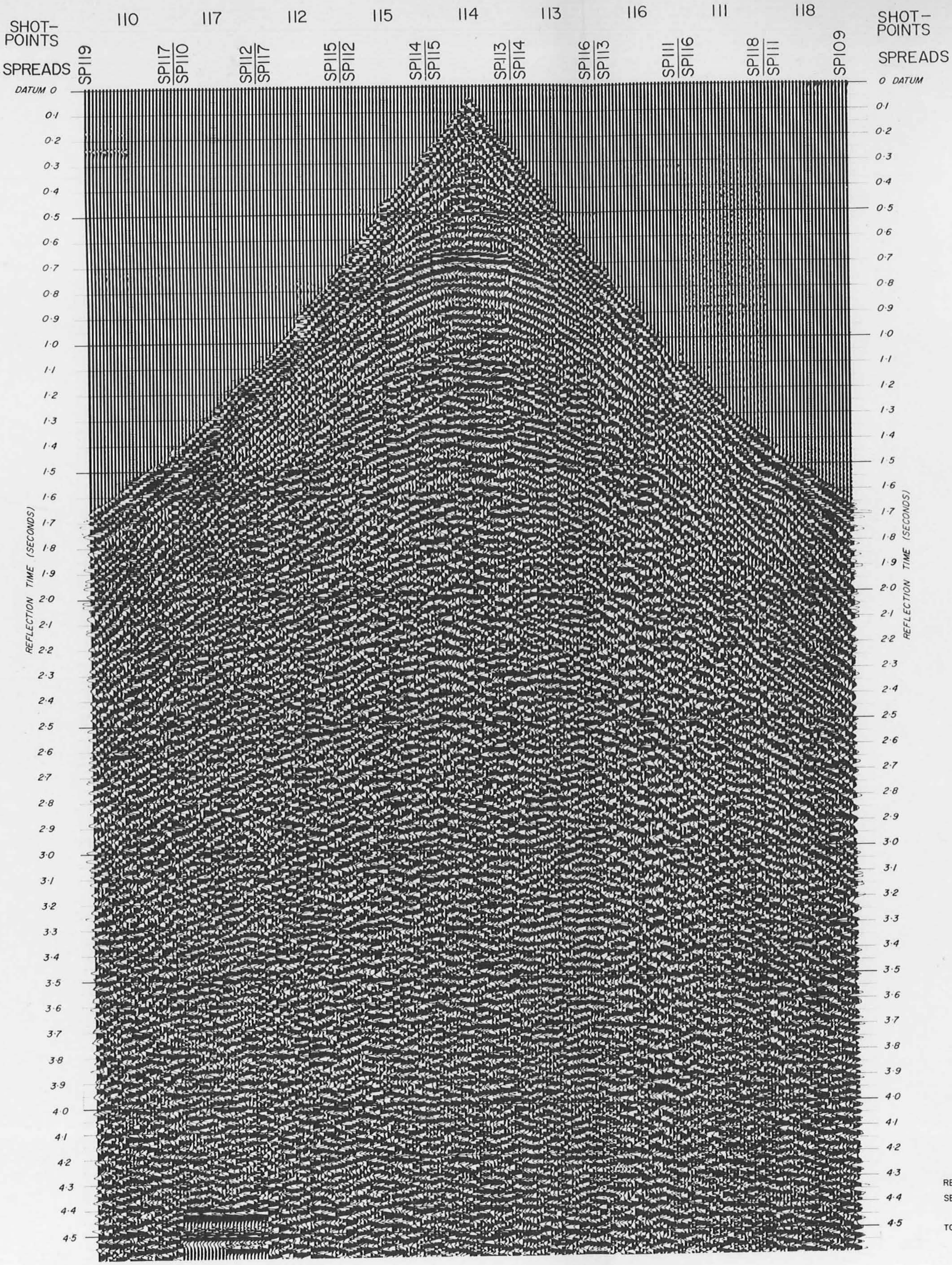

TO ACCOMPANY RECORD No. 1970/52

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

F54/B3—175

PLATE 29

# UNCORRECTED RECORD SECTION




RECORDING INFORMATION

*Magnetic Recorder*: PMR-20

*Amplifiers* : 7000B

*Prefilters*: 18c/s, 12dB/octave

*Filters* : 0-K120

*AGC* : W.B.

*Gain Initial*: -60

*Final*: -10

*Geophones*: HSJ-14c/s

*Geophone Station Interval*: 150'

*Geophone Pattern*:

16/trace, 10' apart in line

*Shot Hole Pattern*:

5 holes, 32' apart in line

Depth 69-75', Charge 5 x 15lb

PLAYBACK INFORMATION

*Filters*: 1/20-1/78

*AGC* : S

*Gain Initial*: -50

*Final*: -30

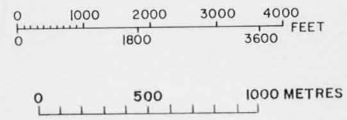
*Trip Delay*: 0 to 0·8s

*Compositing*: Nil

VELOCITY INFORMATION

Nil

HORIZONTAL SCALE




## TRAVERSE A
## EXPANDED SPREAD AT SP114

RECORDED BY: *Seismic Party No. 1*

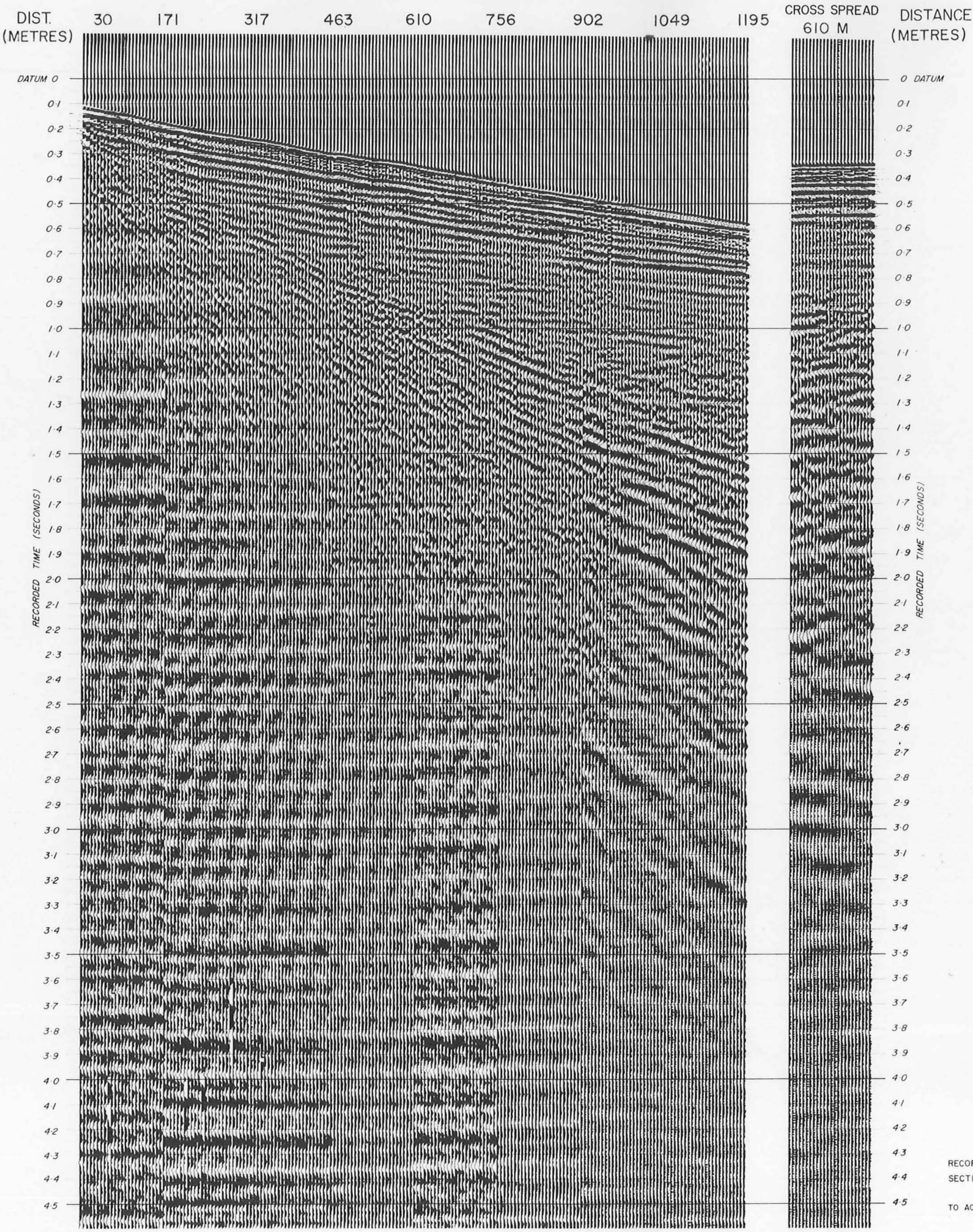
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS42*

TO ACCOMPANY RECORD No. 1970/52

F54/B3-202

PLATE 30

# RECORD SECTION




## RECORDING INFORMATION

*Magnetic Recorder:* PMR-20

*Amplifiers* : 7000B

*Prefilters:* 18c/s, 12dB/octave

*Filters* : 0-K120

*AGC* : Off

*Gain Initial:*
*Final:* } Various

*Geophones:* TIC-20c/s

*Geophone Station Interval* : 20'

*Geophone Pattern* :

Single

*Shot Hole Pattern:*

Single
Depth 71-75', Charge 10lb

## PLAYBACK INFORMATION

*Filters:* 0-0

*AGC* : S

*Gain Initial:* -40

*Final* : -10

*Trip Delay* : Varied

*Compositing:* Nil

## VELOCITY INFORMATION

Nil

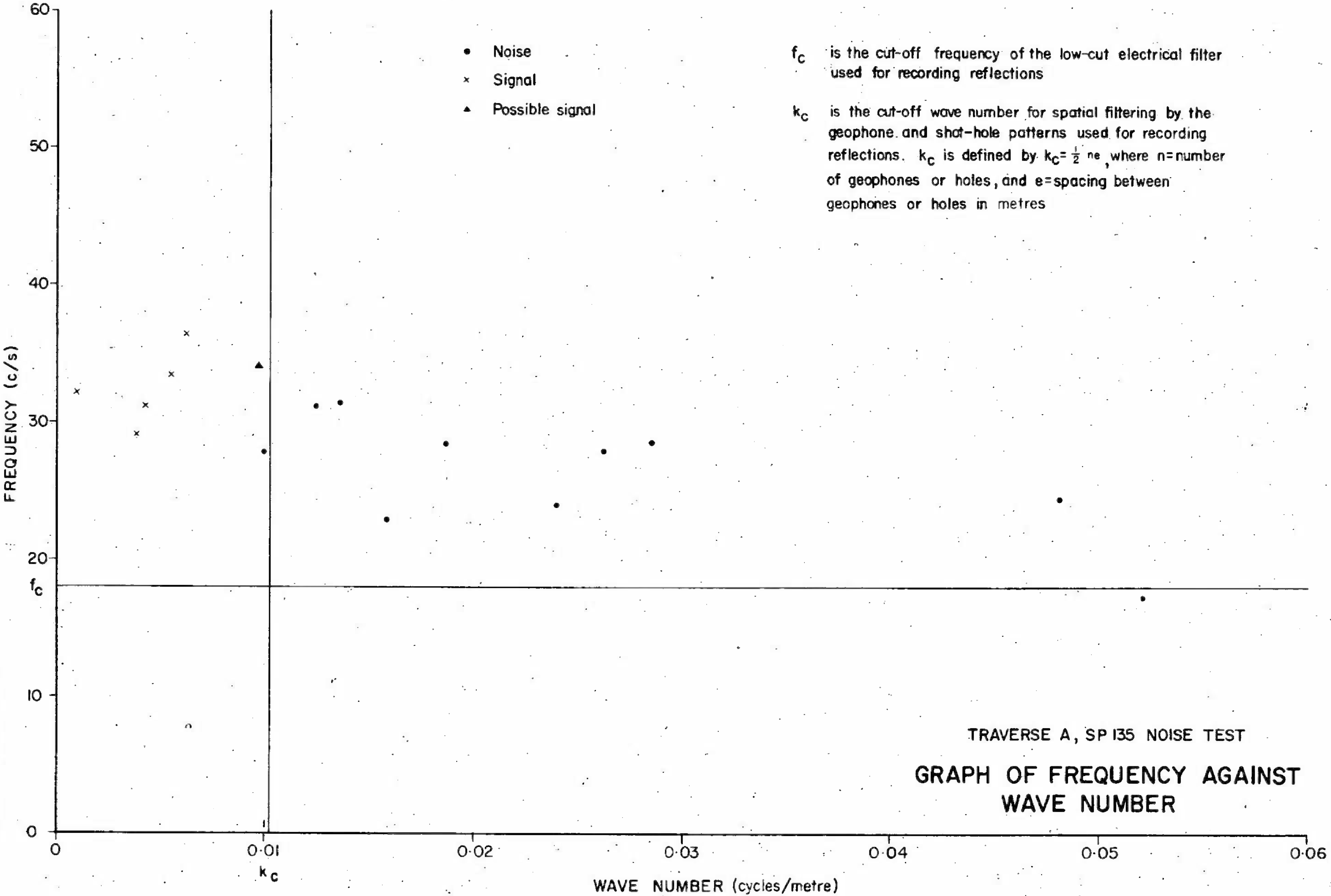
HORIZONTAL SCALE

As indicated

## TRAVERSE A
## NOISE TEST SP135

RECORDED BY: *Seismic Party No. 1*
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS42*
TO ACCOMPANY RECORD No. 1970/52

F54/B3-203




TRAVERSE A, SP 135 NOISE TEST

## GRAPH OF FREQUENCY AGAINST WAVE NUMBER

PLATE 31

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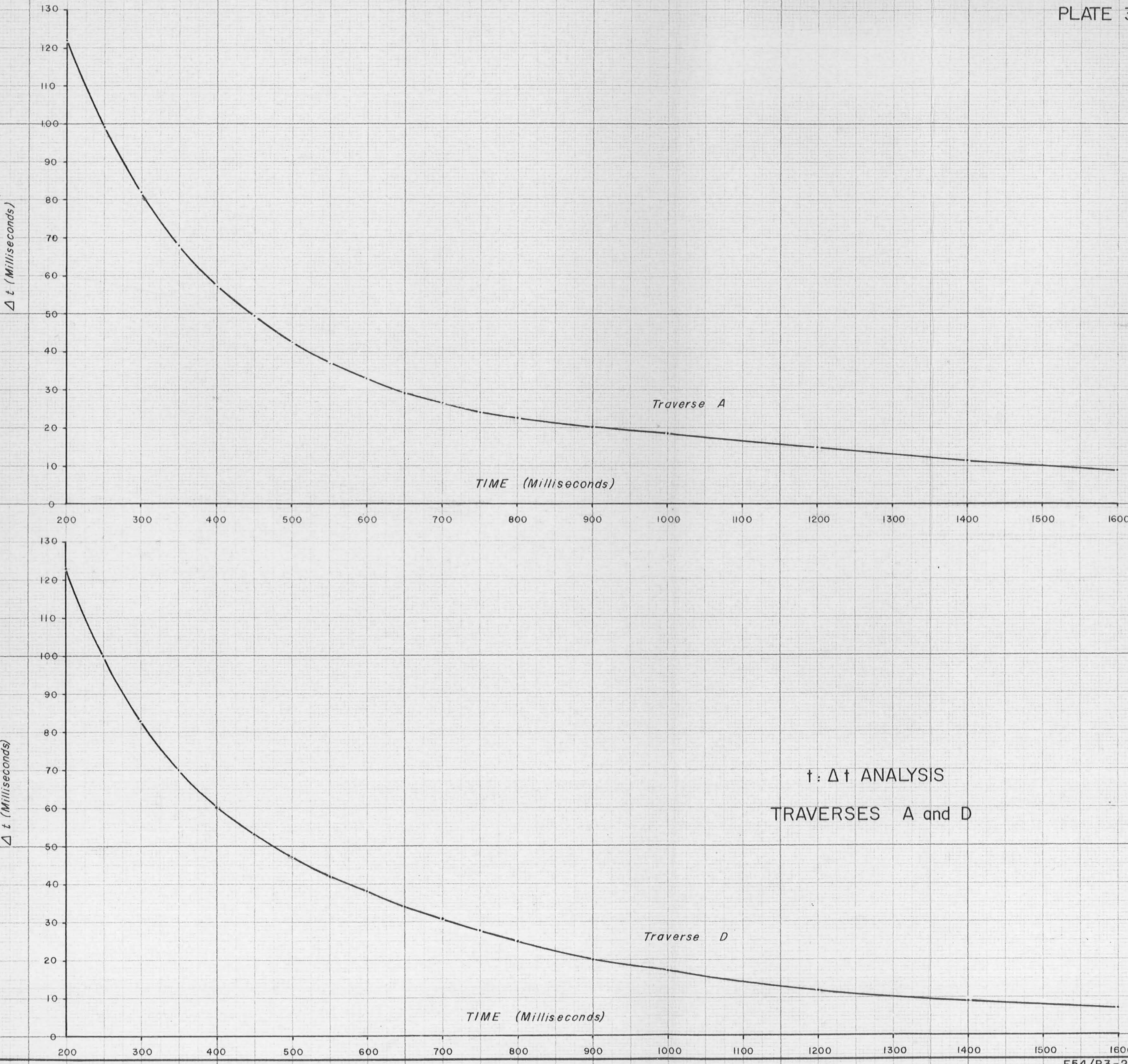
TO ACCOMPANY RECORD No. 1970/52
F 54/B3—186

PLATE 32




## t : Δt ANALYSIS

## TRAVERSES A and D

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

TO ACCOMPANY RECORD No. 1970/52

F54/B3-208