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# GILES-CARNEGIE SEISMIC SURVEY, WESTERN AUSTRALIA 1961-1962

by

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## ILLUSTRATIONS

## SUMMARY

During parts of the 1961 and 1962 field seasons a reconnaissance seismic survey was made along the Weapons Research Establishment road from Giles Meteorological Station to Carnegie Homestead in Western Australia. The main investigation was directed at the sedimentary section in the trough between the Musgrave Block in the east and the Yilgarn Block in the west.

Surface geological investigation had shown a thin layer of flat-lying Permian, Mesozoic, and Cainozoic rocks blanketing the area from the Canning Basin in the north to the Officer Basin in the south and resting unconformably on Precambrian rocks at east and west margins. There was evidence that a thick sedimentary section might be present in the area and it was also known that thick Proterozoic sedimentary sequences exist both east and west of the area.

In 1962 the results of a reconnaissance gravity survey carried out by the BMR showed that the main seismic investigation was being conducted within the area of a major gravity 'low', the Gibson Gravity Depression; the eastern part of the line from Signpost to Mount Beadell crosses an elongated north-west trending 'low', the Mount Samuel Gravity Low; the western part of the line from Mount Everard to Carnegie Homestead crosses the Herbert Gravity Sub-Depression.

Since 1962 other geophysical and geological work has been carried out in the area by the lease-holders culminating in the drilling by Hunt Oil Company of Yowalga No. 2 well to 3250 feet. In this report the results of the BMR seismic survey have been interpreted in the light of the more recent information.

Refraction velocities associated with known main rock sequences were determined on outcrops to the east of the area. The survey was then continued westward carrying out refraction probes at about 30-mile intervals. Two principal refractors within the sedimentary section could be correlated from probe to probe. These were firstly a velocity between 10,000 and 11,000 ft/s, which is interpreted as being near the top of the Permian section, and secondly a velocity between 16,300 and 17,000 ft/s, which is interpreted as being near the top of the Proterozoic section.

Short reflection traverses were recorded over most of the refraction probes west of Signpost to test the effectiveness of the reflection method for mapping structure in the area and to assist in the interpretation of the refraction probes. The reflection method was shown to be capable of giving usable results on areas of Cretaceous outcrop provided sufficiently large numbers of holes and geophones are used in two-dimensional arrays.

The maximum depth to the 16,300 to 17,000 ft/s refractor was about 5000 feet. It was thought that the unknown section at shallower depth might be explained by the Lower Palaeozoic to Upper Proterozoic sandstone mapped at the Iragana Inlier. In fact a red sandstone which is thought to be of Upper Proterozoic age was penetrated at this position in the section by Yowalga No. 2 well.

The amount of seismic evidence obtained showing the depth to metamorphic basement was small. A few measurements were made of a refractor having a velocity of about 20,500 ft/s at depths of 15,000 to 19,000 feet in the Mount Samuel Gravity Low. A fair reflection was obtained from a depth of about 38,000 feet in the Herbert Gravity Sub-Depression. A thick Proterozoic sedimentary section is indicated in both areas.

Strong angular unconformity was demonstrated by the Yowalga Seismic Survey at Horizon A, which appears to correlate with the 16,300 to 17,000 ft/s refractor. Various scattered results of the BMR survey, obtained by both reflection and refraction methods, show this unconformity. Possible diapiric or decollement-type folds are postulated as being crossed by the BMR line just west of Mount Charles, between Mount Samuel and NMF 19, and at Lake Keene.

## INTRODUCTION

Until recent years the Gibson Desert area of Western Australia was relatively unexplored. The only tracks entering the area (Plate 1) were those from Alice Springs via Blackstone Camp to Warburton Mission and from Leonora to Warburton Mission; a road from Wiluna stopped at Carnegie Homestead on the western margin of the area; the Canning Stock Route passed on the north-west. Exploration has now forged ahead, getting its impetus from two sources: the inclusion of the area in the firing range for the Weapons Research Establishment (W.R.E.); and the search for oil.

In 1958, a survey party from W.R.E. and the Division of National Mapping made a ground reconnaissance from Signpost, near Warburton Mission, to Carnegie Homestead (Johnson, 1958) and, in 1959 to 1960, a dirt road was constructed by W.R.E. along the line of that reconnaissance. Prior to this, W.R.E. had established Giles Weather Station and had constructed a road from Giles to Warburton in 1958. Since then other roads have been constructed by W.R.E. throughout the area. A useful description of the area between Giles and Carnegie is given by Johnson. It is interesting to note that more than 4 years later the wheel-tracks of a Land Rover belonging to the original reconnaissance party could be followed for 7 miles south-west from NMF 23.

In mid 1960, Leslie (1961) carried out a geological reconnaissance for Frome-Broken Hill Pty Ltd in the Gibson Desert area; in particular he carried out a reconnaissance along the Giles-Carnegie road, which ran centrally through this area. At the commencement of the seismic survey described in this Record, the report by Leslie was the only fairly comprehensive statement on the geology of that part of the Gibson Desert area where the principal seismic investigation was proposed. Since 1960, widespread geological and geophysical surveys have been made in the area (see Chapters 2 and 3).

The main part of the seismic survey was made along the road from Giles to Carnegie during parts of the 1961 and 1962 field seasons. Its purpose was to investigate the sedimentary section in the trough between the two areas of Precambrian outcrop, one lying east from Signpost (the Musgrave Block) and the other west of Carnegie Homestead (the Yilgarn Block).

The seismic traverses were laid out by the side of the road, which was well suited for the purpose because of its very long straight stretches. Several refraction traverses were extended to such lengths that the road had to be left and difficult country was traversed; the whole of the Lake Keene traverse lies 40 miles off the road.

The results of the survey are discussed and interpreted in the light of more recent work. Although this has not affected the main conclusions of the survey, it has enabled tentative interpretations to be made of various results that were previously unexplained.

Main camps were set up, in 1961, near the water bore 11 miles south of Signpost and, in 1962, half-way between NMF 19 and Mount Beadell. In both years initial supplies were carried from Alice Springs. In 1961 additional supplies were obtained from Alice Springs and one additional supply run was made to Leonora. In 1962 further supplies were obtained through the railhead at Meekatharra 520 miles from camp; stores and petrol were collected from Carnegie Homestead 190 miles from camp where they were delivered fortnightly by carrier from Meekatharra.

Water for both drilling and camp use was obtained mainly from bores drilled by the seismic party. A short note concerning these bores is given in Appendix D. Further information concerning underground water supplies in the area is given by Sofoulis (1962, 1963) and Jackson (1966b).

Details of staff, equipment, and operational statistics are given in Appendixes A, B, and C.

## 2. GEOLOGY

The history of geological probes into the Gibson Desert and related neighbouring areas is given by Wells (1963). In the preparations for the seismic survey the following material was consulted: Wells, 1960; Veevers and Wells, 1961; Wells, Forman, and Ranford, 1961 (now replaced by Wells, Forman, and Ranford, 1964); Leslie, 1961; David, 1950; Tectonic Map of Australia (BMR 1960).

A generalised geological map of this area is given in Plate 1. The stratigraphy of the area as known at present is summarised in Table 1.

### Topography, Climate, Vegetation, etc.

Leslie (1961) described three main topographic divisions:

1. Marginal areas with elevations from 1500 to 2000 feet (rarely up to 2500 feet) consisting of dissected hills and ranges accompanied by more mature topography with or without sand ridges. These correspond to areas in which Precambrain rocks are exposed.

2. Meridional bordering zones with strong linear or reticulate sand dunes, low mesas, flat-topped ranges, and breakaway scarps, corresponding to areas of late Palaeozoic glacial sediments and Jurassic sandstones. The base of the sand dune level occurs at about 1500 feet elevation, and few of the flat-topped hills exceed 100 feet above this level.

3. A central semi-plateau area, generally free of sand and dunes, corresponding to areas of Lower Cretaceous mudstones and siltstones. The plateau level occurs at about 1600 feet elevation and overlooks the bordering sand dune zones. Flat-topped hills and ranges, most

TABLE 1

COMPARISON OF THE STRATIGRAPHY OF THE GIBSON DESERT AND SURROUNDING AREAS

| AGE | FORMATIONS AND CORRELATIONS IN NEIGHBOURING AREAS | | | | REMARKS |
|---|---|---|---|---|---|
| | GIBSON DESERT AREA | SOUTH CANNING BASIN | RAWLINSON - MACDONALD | RUNTON RANGE - LAKE CARNEGIE | |
| QUATERNARY | Alluvium, evaporites, aeolian sand, travertine | | | | |
| TERTIARY | Bedded white chalcedony, sandy siliceous limestone (travertinous)<br>30 ft max. | | | | Overlying Cretaceous strata in south-westerly drainage pattern (Leslie, 1961) |
| CRETACEOUS | Bejah Beds<br>Claystone, siltstone, fine sandstone, marine fossils<br>60ft in mesas | 45ft Bejah Hill | | | The Bejah Beds continue south from the south Canning Basin |
| | Siltstone, sandstone, marine fossils and plant spores<br>300ft Young Range bore and outcrop | See remarks column | | | Jurassic and Cretaceous rocks of the Canning Basin form a thin sheet, probably nowhere thicker than 2500 feet. Deposited during one transgression and regression mostly in a shallow sea as conglomeratic sandstone on-shore and claystone and siltstone off-shore, the formations are diachronous and lithology by itself is no guide to correlation. (Veevers and Wells, 1961) |
| JURASSIC OR TRIASSIC | Sandstone, siltstone, worm trails<br>300ft ± Iragana Fault | Lithologically similar to Cronin Sandstone of south Canning Basin | | | |
| PERMIAN | | Liveringa Formation 395ft<br>Noonkanbah Formation 1020ft<br>Poole Sandstone 443ft<br>(Kidson No.1 well) | | | The Permian rocks on the south east and south west of the Canning Basin are poorly exposed except for the Paterson Formation in the south west. Ryan Buttes extending south of 24° Latitude in the south east are tentatively identified as Liveringa Formation (Veevers and Wells, 1961).<br>In the Canning Basin the rocks deposited during the Permian are essentially conformable, each Permian Formation is probably the same age throughout and hence lithology can be used tentatively as a guide to correlation. (Veevers and Wells, 1961) |
| | Coarse and medium sandstone, siltstone, fossil wood and plant spores.<br>500ft ± Iragana Fault<br>Paterson Formation:-<br>Coarse and medium sandstone, siltstone, erratics. Fluvioglacial.<br>100ft ± in mesas on western margins of the Herbert and Madley sheets<br>Coarse to fine sandstone, mudstone<br>1025ft in Yowalga No.2 | Grant Formation, Paterson Formation, Braeside Tillite.<br>Coarse and medium sandstone, siltstone, conglomerate, erratics.<br>2738ft in Kidson No.1 well. | Buck Formation 137ft<br>Sandstone, siltstone and conglomerate | | The Grant Formation, Paterson Formation and Braeside Tillite of the Canning Basin, the Lyons Group of the Carnarvon Basin, the Nangetty Formation of the Perth Basin and probably also the Wilkinson Range beds of the interior plateau contain glacigene rocks. These formations were probably deposited during the Sakmarian. (Veevers and Wells, 1961).<br>The Paterson Formation continues down the western margins of the Herbert and Madley sheets from the south-west margin of the Canning Basin. Greater distances separate the other Permian glacial outcrops and the correlations are more uncertain. |
| UNCERTAIN | | | Ligertwood Beds<br>Sandstone, conglomerate, breccia | | Younger than Maurice Formation, lithology similar to part of Buck Formation (see Wells, Forman and Ranford, 1965) |
| PRE-PERMIAN TO ORDOVICIAN | | Carbonate, shale 876ft<br>Tandalgoo Red Beds 2405ft<br>Carribuddy Formation:-<br>Unit A. Siltstone 1208ft<br>Unit B. Siltstone, sandstone, salt 4899ft<br>(Kidson No.1 well.) | | | WAPET Kidson No.1 well penetrated 9388 feet of pre-Permian section bottoming in Ordovician rocks of the same age as the Upper Stairway Formation of the Amadeus Basin. Large thicknesses of salt were encountered in the bottom 4899 feet. |
| DEVONIAN TO ORDOVICIAN | | | Merenie Sandstone 30ft exposed | | |
| ORDOVICIAN | | | Calcarenite, sandstone, marine fossils<br>10ft | | |
| LOWER PALAEOZOIC TO UPPER PROTEROZOIC | Sandstone, siltstone, greywacke, conglomerate.<br>3000ft ± Iragana Inlier | | Maurice Formation<br>6300ft (photo interpreted)<br>Ellis Sandstone 1995ft \| Sir Frederick Conglomerate 1200ft | Upper Unit - 11,700ft<br>Mainly sandstone with shale and evaporites | |
| UPPER PROTEROZOIC | Medium red-brown and white sandstone and siltstone.<br>12,000ft ± Iragana Inlier<br>Brick red sandstone<br>1055ft Yowalga No.2 | | Carnegie Formation<br>Sandstone, siltstone and minor greywacke<br>4123ft \| Boord Formation<br>Siltstone, dolomite, limestone with stromatolites, basal conglomerate<br>2794ft | Upper Unit<br>Lower Unit - 16,600ft<br>Shale, carbonate, evaporites, sandstone.<br>Correlation of these units is very tentative | Mack and Herrmann infer their Upper Unit to be the time equivalent of the Carnegie Formation to Maurice Formation interval and their Lower Unit to be the time equivalent of the Dixon Range Beds to Carnegie Formation interval.<br>The Carnegie and Boord Formations are lateral equivalents and are correlated with the Areyonga Formation and the Inindia Beds of the Amadeus Basin.<br>Because of lithologic similarities, Jackson (1966a) correlates the red sandstone in Yowalga No.2 with outcrops in the Livesey Range area on the south-eastern edge of the Musgrave Block. The outcrops in this area are mapped as Lower Palaeozoic to Upper Proterozoic. Volcanics are present in the rocks immediately to the north which are mapped as Mid-Proterozoic.<br>Based on isotope age determinations, a minimum age of crystallisation has been determined for the volcanics in Yowalga No.2 as 1000 million years. An age of 445 million years has been determined for metamorphism (Jackson, 1966a)<br>Preliminary age determinations for the Bitter Springs Formation show a similar age. Volcanics are present in the upper part of the Bitter Springs Formation interval in the north-east of the Amadeus Basin. |
| | Volcanics<br>385ft Basalt in Yowalga No.2 | | Bitter Springs Formation<br>Dolomite and limestone with stromatolites, siltstone<br>1200ft | | |
| | Sandstone and shale with veins and fracture fillings of anhydrite and gypsum.<br>135ft in Yowalga No.2 | | | | |
| | Dolomite with veins and fracture fillings of anhydrite and gypsum<br>20ft in Yowalga No.2 | | | | |
| | Shale, siltstone<br>316ft in Yowalga No.2 | | | | |
| | | | Dean Quartzite 3911ft \| Heavitree Quartzite 391 ft | Lower Unit | |
| PRECAMBRIAN | | | Dixon Range Beds 6730ft<br>Sandstone, siltstone, minor arkose and conglomerate | | |
| | Schist, gneiss, granite, basalt | | Schist, gneiss, granite | | |

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NOTES:
1. The stratigraphy and correlations are taken from the following reports:- Wells, 1963; Veevers and Wells, 1961; Wells, Forman and Ranford, 1964; Mack and Herrmann, 1965.
2. The correlation of the Yowalga No.2 Formations is presented as suggested by A.T.Wells.
3. Information concerning Kidson No.1 well is taken from WAPET interim reports.

of which are adjacent to the Giles-Carnegie road, rise to 150 to 200 feet above the general plateau level.

The Cretaceous sediments were overlain in Tertiary times by deposits of bedded white chalcedony, marly chalcedonic breccia, and sandy siliceous limestone (travertinous) and are mantled by a Quaternary covering of red brown clayey soils and laterite rubble.

The climate is that of a dry inland desert area with rainfall less than 8 inches per year and temperatures consistently exceeding 100°F in the summer months. Spinifex covers most of the land surface with sporadic large areas of mulga (acacia) thicket. Surface water may be found in rock holes and claypans following occasional heavy rains. More detailed information concerning climate and vegetation is given by Leslie (1961) and Jackson (1966b).

In 1961 a fresh water lake, Lake Gruska, was found by army surveyors to have several feet of water in it; considerable fauna were present. Towards the end of 1962 when members of the seismic party visited the lake it was dry. At the request of the Forestry and Timber Bureau, K.F. Fowler collected samples of fruit and leaves from trees growing in and around the lake. These were mainly eucalypt, acacia, and ti-tree.

Geology known prior to survey

The area of interest to the seismic survey is surrounded by the Canning Basin to the north, the Amadeus Basin to the north-east, the Musgrave Block to the south-east, the Officer Basin to the south, and the Yilgarn Block to the west (Plate 1).

Veevers and Wells (1961) traced the Canning Basin, from its contact with the sea between Derby and Port Hedland (Western Australia), southward as far as the northern boundaries of the MADLEY, WARRI, COBB, and RAWLINSON 1:250,000 map areas. The eastern and western edges of the basin are shown, in this region, as Precambrain sediments and Precambrian metamorphics, while the main basin sediments continue southward, comprising Permian and undifferentiated Mesozoics across an east-west front about 250 miles wide. The presence of a probable salt dome at Woolnough Hills (Veevers and Wells, 1959a & b), in the north-west of WARRI, indicated the presence of a thick sedimentary section.

To the east of the survey area in MACDONALD and RAWLINSON, Wells, Forman, and Ranford (1964) mapped Proterozoic sediments of aggregate thickness exceeding 20,000 feet in the western part of the Amadeus Basin; there was some doubt at that time as to whether the upper part of the Proterozoic series was early Palaeozoic. On the northern and southern margins of the Amadeus Basin, Upper Proterozoic sediments rest unconformably on older Precambrian rocks, which are regarded as basement. In the western parts of MACDONALD and RAWLINSON, Permian glacials unconformably overlie Proterozoic sediments.

From their survey of RAWLINSON and MACDONALD, Wells, Forman, and Ranford made a brief trip between Giles Weather Station and Carnegie

Homestead examining fossiliferous Mesozoic rocks in the area (Wells, 1960). Between Mount Charles and Young Range, siltstone and sandstones were found in outcrop, which were thought to be the probable continuation of Cretaceous sediments from the Canning Basin; well preserved marine macrofossils occur at Mount Samuel.

Leslie (1961) spent 5½ months on a ground reconnaissance of the area bounded by latitudes 23°S and 29°S and longitudes 123°E and 127.5°E. He mapped Lower Cretaceous sediments of total thickness about 250 feet, which extended south from the Canning Basin and covered most of the central part of the area surveyed. Two unconformable Mesozoic units, thought to be of Jurassic age, amounted to only 100 feet in thickness. Permian glacials cropped out mainly in the western and southern parts of the area, with a maximum thickness of 750 feet measured on the rim structure of the diapir at Woolnough Hills. Leslie stated that this diapir included Upper Proterozoic rocks in the core.

Further evidence of a thick sedimentary section had been found by Goodeve (1961) when an aeromagnetic reconnaissance indicated a possible 10,000 feet of non-magnetic rocks east of Mount Charles.

The Tectonic Map of Australia shows Archaean and Proterozoic rocks cropping out east from south of Mount Charles, and west of Carnegie Homestead.

At the start of the seismic survey, therefore, it was known:

(a) that a thick sedimentary section was likely to exist in the survey area,

(b) that thick Proterozoic sedimentary sequences exist both east and west of the survey area, and

(c) that Permian, Mesozoic, and Cainozoic rocks, mostly flat-lying to sub-horizontal and not known to have a total thickness greater than 1200 feet, blanket the area from the Canning Basin in the north to the Officer Basin in the south and rest unconformably on Precambrian rocks at the east and west margins of this area.

Very little was known concerning:

(a) significant variations in thickness of Permian and Mesozoic rocks,

(b) the presence of Palaeozoic rocks other than Permian glacials,

(c) the nature of the Precambrian floor of the basin, i.e. whether it was Proterozoic or Archaean, or

(d) the tectonic history of the area.

Recent geological knowledge

A.T. Wells of the BMR Geological Branch travelled throughout the Gibson Desert area by helicopter accompanying the regional gravity survey by the Geophysical Branch in June and July 1962. A summary of the stratigraphy described in his report (Wells, 1963) is shown in column 2 of Table 1.

From 1960, Hunt Oil Company operated permits to explore in an area bounded by latitudes 25°S and 30°S and by longitudes 123°E and 129°E plus KINGSTON, but excluding HERBERT. Some surface geological mapping was done, and in 1962 and 1963, a photogeologic study was made. Four shallow scout wells were drilled in 1965. Although none of this work was published, the results have been described in reports of geophysical surveys under the Petroleum Search Subsidy Act and in the well completion report of Yowalga No. 2 (Jackson, 1966a), which was also subsidised.

The photogeologic study is said to have defined numerous anticlinal belts as well as several structures which can possibly be classified as diapiric in origin, although it is later stated that surface flexures are almost totally absent and that the indication of subsurface structure is only slight.

A generalised geological map in the well completion report for Yowalga No. 2 shows a summary of the field geology and photogeology. The principal structural features are shown in Plate 1. It is seen that most anticlinal trends in BROWNE, BENTLEY, YOWALGA, and TALBOT are north-west.

Three of the scout wells were sited in the area defined by the Mount Samuel Gravity Low (Plate 2), Browne Nos. 1 and 2 on the axis near the gravity minimum and Yowalga No. 1 twenty miles south of the axis on the minus 70-milligal contour. Each of these wells was sited on the crest of an anticline located by seismic traversing (see Chapter 3). The fourth hole, Lennis No. 1, was one hundred miles to the south-south-east in the north-west of LENNIS and in the centre of the North Lennis Gravity Depression (Bazhaw and Jackson, 1965). This well was sited on a much flatter section according to the seismic evidence.

Early in 1966 Yowalga No. 2 was drilled on a site close to that of Yowalga No. 1 to a total depth of 3246 feet.

Table 2 gives a brief summary of the lithology encountered in the above wells and its interpretation (see pages 6 and 7).

In 1965 a reconnaissance geological survey of the Gibson Desert and surrounding areas was made for Union Oil Development Corporation by Mack and Herrmann (1965). They state that 28,000 feet of Upper Proterozoic to Cambrian (?) sedimentary rocks are exposed on the western margin of the Gibson Desert area within a south-easterly striking structural depression. This depression lies between areas of Archaean to Lower Proterozoic granite, metamorphics, and volcanics to the south-west of Lake Carnegie and to the north of Lake Disappointment. Folding in the outcropping sediments is characterised by thin elongated and faulted anticlines separated by broad synclines. Disharmonic folding of incompetent shale,

TABLE 2

Lithology and interpretation of wells drilled by Hunt Oil Company

| Browne No. 1 | Browne No. 2 | Lennis No. 1 | Yowalga No. 2 | Lithology | Age |
|---|---|---|---|---|---|
| 0 - 277ft | 0 - 460ft | 0 - 450ft | 25 - 310ft | Laterite, claystone, sandstone, siltstone | Mesozoic |
| 277 - 435ft | 460 - 860ft | 450 - 730ft | 310 - 1335ft | Sandstone | Lower Permian |
| | | 730 - 2009ft | 1335 - 2390ft | Brick red arkosic Sandstone | Upper Proterozoic? (No palaeontological evidence. Age estimate based on lithological correlation) |
| | | 2009 - 2016ft (T.D.) | 2390 - 2775ft | Tuff, basalt | Upper Proterozoic |
| 435 - 1269ft (T.D.) | 860 - 960ft (T.D.) | | | Limestone, shale, gypsum | Upper Proterozoic? |
| | | | 2775 - 2910ft | Sandstone, containing fracture fillings of anhydrite and gypsum | Upper Proterozoic |

| Browne No. 1 | Browne No. 2 | Lennis No. 1 | Yowalga No. 2 | Lithology | Age |
|---|---|---|---|---|---|
| | | | 2910 - 2930ft | Dolomite containing fracture fillings of anhydrite and gypsum | Upper Proterozoic |
| | | | 2930 - 3246ft (T.D.) | Shale, siltstone | Upper Proterozoic |

carbonate, and evaporite beds relative to the more competent sandstone is evident in outcrop and suggests a decollement style of folding. Mack and Herrmann state that they recognised similar decollement-type folds in the MacDonald-Bloods Range area and in the western end of the Amadeus Basin, where gypsum, shale, and carbonate beds from the Bitter Springs Formation are disharmonically folded in the cores of the elongated anticlines.

Webb (1965) makes the following summary remarks concerning structures in the neighbouring Amadeus Basin. "Spectacular anticlinal structures occur in the Amadeus Basin along trends 60 to 80 miles long paralleling the basin edges. Individual closed anticlines range from 10 to 30 miles in length. Some are deeply breached but some are closed in Ordovician or younger beds. The structures are characterised by gravity minima and are thought to be due to movement of salt from Upper Proterozoic sources". He also speculates to the effect that diapiric structures are known in both the Amadeus and Officer Basins and that the Officer Basin might have a history of deformation similar to that of the Amadeus Basin.

These speculations are in general agreement with the surface geological structure mapped in the central area by Hunt Oil Company and in the west by Mack and Herrmann. In the area of the Mount Samuel Gravity Low they are supported by the results of the Yowalga seismic survey and the Lennis-Breaden gravity surveys (see Chapter 3).

The results of the Yowalga seismic survey show that fairly strong folding has taken place below Horizon A, which is equivalent to the volcanics in Yowalga No. 2 and to the limestone, shale, and gypsum in Browne Nos. 1 and 2. Also the folded sedimentary section probably extends 15,000 feet or more below this horizon. The evidence of salt movement in the area and the form of the associated local gravity anomalies support the theory that this folding was associated with salt movement. Both decollement and diapiric-type folding are probably present. Folding is parallel to the axis of the trough associated with the Mount Samuel Gravity Low.

Subsequent to the major folding, erosion has taken place, a volcanic layer has been formed on the eroded surface, and about a thousand feet of red sandstone has been deposited, probably all within the Proterozoic era. It seems possible that the limestone, shale, and gypsum encountered in Browne Nos. 1 and 2 and the anhydrite and gypsum encountered below the volcanics in Yowalga No. 2 may have a common source. The red sandstone and the volcanics encountered in Yowalga No.2 may be missing in the Browne wells through lack of deposition or erosion.

Folding appears to have continued after the major erosion and is reflected in the surface trends mapped by photogeology; however, these surface anticlines could very well be depositional in origin.

If the volcanic basalt is the time equivalent of the Bitter Springs Formation of the Amadeus Basin (see note in Table 1), it seems that the folded sediments must be older than the Bitter Springs Formation.

An up-to-date geological map of Western Australia was published in 1966 by the Geological Survey of Western Australia. Some of the geology from this map is shown in Plate 1, particularly on the western edge of the area covered.

Jackson (1966b) has made a comprehensive review of the geology of the area included in the oil exploration permits operated by Hunt Oil Company. More detailed information is given concerning the geological exploration carried out for Hunt Oil Company. This review came to hand after the present report was written.

## 3. OTHER GEOPHYSICAL WORK IN THE SURVEY AREA

### Aeromagnetic surveys

A map showing contours of depth to magnetic basement interpreted from aeromagnetic surveys in the area is presented in Plate 3.

An aeromagnetic survey made by the Bureau of Mineral Resources (Goodeve, 1961) showed shallow magnetic basement in a marked narrow anomaly running north-west from Signpost. This anomaly was interpreted as arising from a structure which is shallow near Signpost and which deepens possibly to 10,000 feet as it extends under the sedimentary basin. Further indications from this survey were that there could be a thickness of more than 5000 feet of non-magnetic material west of Mount Charles to beyond Mount Beadell.

During 1961, reconnaissance aeromagnetic lines with 30-mile spacing were flown for Hunt Oil Company in an area bounded approximately by latitudes 24°S and 30°S and by longitudes 123°E and 129°E. The report on this survey has not been published, but a map showing the interpreted depth to basement is included in the review by Jackson (1966b). A sedimentary thickness in excess of 12,000 feet is shown overlying magnetic basement throughout most of the area of the Lennis-Breaden gravity survey (see Chapter 3). A thickness of 18,000 feet is shown in the area of the Yowalga No. 1 and No. 2 wells.

During 1965, a band-type aeromagnetic survey was flown in the Gibson Desert area by Aero Service Ltd for Union Oil Development Corporation and Kern County Land Company. The survey consisted of 20,000 line miles of traverse and covered RUNTON, MORRIS, RYAN, MADLEY, WARRI, COBB, and HERBERT. It was arranged in bands six miles apart, each band consisting of three east-west lines at one-mile intervals. An interpretation by Lynch (1965) shows depths to magnetic basement in excess of 25,000 feet. The greatest thicknesses of non-magnetic rocks occur:

(1) At the eastern edge of RYAN and COBB; a western extension of the Amadeus Basin.

(2) In the north-east and north-west of MORRIS and RYAN respectively; a southern extension of the Canning Basin.

(3) In the north-west of the survey area, an isolated north-west trending basin mostly in RUNTON but extending into MORRIS, MADLEY, and WARRI in the south-east and into GUNANYA on the north-west to an unknown extent. This basin coincides with the Runton Gravity Sub-Depression (Lonsdale and Flavelle, 1963) mentioned later in Chapter 3. The Woolnough Hills Salt Dome lies at the south-eastern end of this basin, where the depth to magnetic basement is about 24,000 feet.

(4) In the north-east of HERBERT, a somewhat smaller 'low'; a north westerly extension of the Officer Basin.

Gravity surveys

A map showing Bouguer anomaly contours reduced from gravity surveys in the area is presented in Plate 2.

In mid 1962, a BMR party, using helicopters, made a regional gravity survey which included the area of the seismic survey (Lonsdale and Flavelle, 1963). Stations were on a five-mile grid. Preliminary Bouguer anomalies are shown in Plate 2. The nomenclature of gravity features as used in this report has been taken from Lonsdale and Flavelle. It should be noted that the standard nomenclature as used by the BMR has now been changed - e.g. see Vale, 1965.

The road from Giles Weather Station to Carnegie Homestead crosses two major gravity 'low' regions, the Cobb Gravity Depression and the Gibson Gravity Depression. These are separated by a marked gravity ridge running north-west from Signpost, the Warri Gravity Ridge, which is more or less coincident with the magnetic basement ridge found by Goodeve (1961).

From the results of the gravity survey it was found that the main BMR seismic investigation was being carried out within the Gibson Gravity Depression. The first part of the survey, from Signpost to Mount Beadell, crossed an elongated north-west trending 'low', Feature No. 6 - the Mount Samuel Gravity Low; the second part of the survey, west from Mount Everard would pass to the south of the central 'low' of Feature No. 1 - the Herbert Gravity Sub-Depression.

Another major low feature within the Gibson Gravity Depression is another elongated north-west trending basin, Feature No. 3 - the Runton Gravity Sub-Depression. This lies to the north, separated from the Herbert Gravity Sub-Depression by Feature No. 2 - the Madley Gravity Swell. In the south-eastern end of this basin is a more localised deeper 'low', which contains the Woolnough Hills Salt Dome and which has been given the more particular name of the Woolnough Hills Gravity Low - Feature No. 4.

Between April 1963 and March 1965, Hunt Oil Company made a gravity survey covering BROWNE, most of YOWALGA, the south-western half of TALBOT, the northern halves of WESTWOOD and LENNIS, the south-western corners of BENTLEY and COOPER, and the north-western corner of WAIGEN (Bazhaw and Jackson, 1965).

Two sizes of grid were used: 2 x 6 miles (mostly that part north of latitude 27°S), and 4 x 4 miles. Gravity was read every half-mile along each line - a total of 35,265 stations.

No major changes were made to the regional gravity picture in BROWNE and the south-western corner of BENTLEY already surveyed by the BMR. However, many new local features were outlined and the coverage was extended to the south.

The Mount Samuel Gravity Low extends into the north-western corner of TALBOT. The gravity 'high' in south-west BROWNE, Feature No. 5, extends to the south. The general low area (bounded by the minus 40-mgal contour) between this 'high' and the Warri Gravity Ridge widens to the south, where it joins the eastern Officer Basin (Adastra Hunting Geophysics Pty Ltd, 1965).

Local gravity anomalies of many types, ranging in size from a few square miles to several hundred square miles, are scattered throughout the area. Certain of the anomalies are coincident with surface structure, although the majority have no correlation with known features.

## Seismic surveys

The seismic survey that is the subject of this report was the first seismic work to be done in the area and preliminary reports were issued (Watson, 1963; Fowler, 1963).

Since then, four seismic surveys have been made for Hunt Oil Company within the area of the Lennis-Breaden gravity survey. These were the Babbagoola, Warburton, Yowalga, and Lennis seismic surveys. The Lennis survey was far from the BMR survey and will not be mentioned again.

### Babbagoola seismic survey.

This survey was done by Seismograph Services Ltd in 1963 using the 'Vibroseis' method (Kendall and Hartley, 1964). The survey started with a noise test. The strongest family of noise alignments had a velocity of about 3200 ft/s. The surface waves, having a velocity about 1600 ft/s, and the air wave were also present. Other events had velocities ranging from 5000 to 10,000 ft/s.

Comparisons were made between in-line and transposed techniques. Continuing with the transposed technique, experiments were made with regard to size and type of geophone patch, frequency band, and offset.

The values of the parameters were varied during production but were mostly:

Line 1 Transposed method

400 geophones in a patch 600 x 200 feet

Offset distance 1320 to 2640 feet

Vibrator pattern 396 or 528 feet in-line

Sweeps per trace 20

Sweep frequency 14-40 c/s

Number of vibrators 3

Line 4 SW  Transposed method

300 geophones in a patch 600 or 400 feet x 200 feet

Offset distance 2640 to 3960 feet

Vibrator pattern 396 feet in-line

Sweeps per trace 10 or 20

Sweep frequency 14-40 c/s

Number of vibrators 3

Line 4 NE  10-fold continuous-depth-point (C.D.P.) method

40 geophones per trace in 2 lines 400 feet long and 20 feet apart

Offset distance 1386 to 3894 feet

Vibrator pattern 396 feet in line

Sweeps per trace 10

Sweep frequency 14-40 c/s

Number of vibrators 3

On Line 1, an event at 0.5 to 0.7 second (Horizon A) was fairly continuous along the line. Deeper events occurred sporadically.

The north-eastern half of Line 4 was completed using the 10-fold C.D.P. method. The south-western half was completed using the transposed method. Horizon A was continuous on both parts of the traverse. The deeper information is better with the transposed method. A slightly improved C.D.P. section was obtained from a 5-fold stack of only the five longest offset samples.

<u>Warburton seismic survey</u>. The survey was done by Geophysical Associates Pty Ltd in 1964 and consisted of both refraction and reflection work (Hunt Oil Company, 1965).

On refraction Line MM, continuous time/distance curves were recorded in both directions between two shot-points 101, 480 feet apart. The spread was 13,570 feet long consisting of 24 geophone stations (4 geophones per station) 590 feet apart with a 3-station overlap between adjacent spreads. The refractor velocities derived from the curves were:

| Average refractor velocity (ft/s) | | Depth below 1500 feet A.S.L. (feet) |
|---|---|---|
| $V_1$ | 6250 | |
| $V_2$ | 9550 | 595 |
| $V_3$ | 16,800 | 2385 |
| $V_4$ | 18,650 | 10,515 |
| $V_5$ | 21,400 | 19,345 |

First breaks were picked out to a shot-to-geophone distance of 15,000 feet. Beyond this distance later phases were picked up to about a second after the presumed first breaks. In the region where $V_4$ was picked, $V_3$ must have been interfering with it and in the region where $V_5$ was picked $V_4$ and $V_3$ must have been interfering with it. Reverse coverage was not obtained on the various refractors and considerable structure has since been demonstrated along the traverse (Mickleberry, 1964). The accuracy of the velocity and depth determinations listed above must be doubtful.

On Line AA the basement refractor ($V_5$) was followed continuously from Warburton Mission, where it was just below the surface, south-westwards on the road to Laverton, where it plunged to a depth of 20,000 feet in a distance of 20 miles. The interpretation shows a monocline. The shot-to-geophone distance ranged from 1180 to 136,290 feet.

At the start of the reflection work a noise shoot was recorded. This consisted of one spread of 24 geophone stations 30 feet apart with one group of 8 geophones in a bunch at each station. A further noise test was recorded later in the survey with a geophone station interval of 110 feet.

Experimental reflection shots were recorded to compare the effectiveness of shot-hole patterns, geophone patterns, and offsets.

The method adopted for production reflection shooting on Lines BB, EE, and FF was 'skip-continuous'; shots were recorded from 1560 feet off each end of a 1560-ft spread. A charge of 50 to 110lb was used in a single hole 50 feet deep. Ammonium nitrate/diesoline mixture was used wherever possible. The geophone pattern used was 16 geophones at 17-ft intervals.

On Line BB there is reflected energy at 0.5 to 0.7 second (Horizon A) but continuity is poor. Deeper events are almost entirely absent.

Line DD was shot using a 6-fold C.D.P. method. A split spread was used with 220 feet between geophone stations and 16 geophones at 17-ft intervals per station. A shot was fired every 440 feet with a charge between 30 and 110 lb in a single hole.

The 6-fold C.D.P. stack on Line DD gave a continuous event at 0.6 to 0.7 second over part of the traverse and again there is no deeper information. Sporadic events are continuous over two or three records but conflicting dips and lack of character prevent interpretation.

Yowalga seismic survey. This survey was done by Ray Geophysical Division in 1965 using the 'Thumper' method (Mickleberry, 1964). The survey was started with a noise recording. Two strong noise events had velocities of 3400 and 1600 ft/s. From the noise analysis, a patch was designed using 288 geophones and measuring 575 feet in line with the traverse by 253 feet perpendicular to it. Comparisons were made between in-line and circular drop patterns. The circular patterns proved more effective and both 400-ft diameter overlapped circles with 36 drops per circle and 200-ft diameter tangent circles with 24 and 36 drops were used on Line 32B. Both through-the-patch and in-line-extended methods were used with offset distances ranging from 0 to 2000 feet and from 4000 to 6000 feet respectively. A further set of noise analyses was made using various patch sizes, some of which were suitable for C.D.P. recording. The six-fold C.D.P. technique gave better results and was used for the remainder of the survey. A geophone patch 400 feet in line with the traverse by 200 feet perpendicular to it was used for practically all of the C.D.P. work. The number of geophones was varied from 72 to 108. The in-line method of dropping, using three lines of drops, was adopted as standard until, with the introduction of a second weight truck, a change was made to two lines. 400-ft drop segments were used through most of the area with the number of drops per segment ranging from 40 to 60.

The survey consisted of 19 traversès ranging in length from 8 to 24 miles. On almost all the traverses, the shallow reflection (Horizon A) was an outstanding event and occurred at times from 0.28 to 1.07 seconds (1160 to 5025 feet). A second deeper reflection (Horizon B) occurs at times between 0.75 and 1.77 seconds (3375 to 10,350 feet); this reflection is continuous only sporadically and, as it is part of a sequence of reflections with conformable dips, it is doubtful whether the same reflector has been mapped throughout this horizon.

Similar structure is shown by both Horizons A and B, but the dips on Horizon B are steeper and the deeper beds are seen truncating at the unconformity defined by Horizon A; in particular, Horizon B is truncated in places.

Reflection Horizon A is easily recognisable on most of the Yowalga traverses, firstly because it is the strongest reflection and secondly because of the strong angular unconformity beneath it. However, if this reflection is examined more closely, it is seen to be a complex event varying in strength and character throughout the area. Deeper reflections, some as strong as or even stronger than the main reflection, are seen to be continually converging and coalescing with it, or alternatively diverging from it. The reflection at Horizon B is a function of the strength of the reflection at Horizon A. In particular, where the Horizon-A reflection becomes weak the Horizon-B reflection becomes strong. This happens at the northern end of Line 32J, which is the nearest point of approach to the NMF 19 and Mount Beadell traverses. The Horizon-B reflection is seen clearly as the strongest of a suite of conformable reflections.

Reflections that are fairly obviously primary occur down to the bottom of the 3-second cross-sections throughout most of the area. Most of the reflections seem to be primary. The deeper reflections are not always continuous but become stronger sporadically. In places they are present as an almost continuous wave from Horizon A down. This effect is present at the northern end of Line 17F.

Comparison of Hunt seismic surveys. Line BB of the Warburton survey coincides with Line 1 of the Babbagoola survey. The 'Vibroseis' section shows more continuity on Horizon A and more deeper information.

Line 4 of the Babbagoola survey, Line DD of the Warburton survey, and Line 53J of the Yowalga survey were run parallel to and close to one another. The reflection section obtained by the shot-hole method with six-fold C.D.P. stack on Line DD lacked continuity on Horizon A and deeper information was almost entirely absent. The 'Thumper' section on Line 53J had been obtained by a six-fold C.D.P. stack. Horizon A is strong and continuous and much good quality deeper information is present although sporadic. The 'Vibroseis' section has been obtained by the transposed method on the south-western half and by a five-fold C.D.P. stack on the north-eastern half of Line 4. The transposed method gives a section approximately equal to the 'Thumper' section in quality and in information present. The five-fold C.D.P. stack gives a section which is equal to the 'Thumper' section at the level of Horizon A but which lacks deeper information. Exact comparison of the 'Vibroseis' and 'Thumper' sections is made difficult by the fact that 5/4 and 3/2 composites have been used on the 'Vibroseis' sections and a 2/0 composite on the 'Thumper' section.

The failure of the 'Vibroseis' C.D.P. section to provide deeper information may be the fault of the velocity function used. Dynamic corrections for the 'Thumper' were determined from the results of an expanded-spread velocity shoot on Line 13C. The time/depth curve obtained is shown in Plate 14. It is similar to the curve obtained at Mount Beadell down to 10,000 feet but departs from similarity below this depth and must surely be in error as it shows an interval velocity increasing uniformly to about 100,000 ft/s at a depth of 20,000 feet. However, the dynamic corrections used in obtaining the 'Thumper' sections were effective in revealing deep information and were based on a velocity distribution considerably different from the constant 10,000 ft/s assumed for the 'Vibroseis' corrections.

Geological discussion

The sediments deeper than Horizon A have undergone fairly strong folding followed by erosion. The folding has continued to a less extent subsequent to the erosion. The geological discussion in Chapter 2 points to this folding being due to salt movement. This view is strengthened by the presence of what appears to be well-developed piercing in one of these folds. This will be discussed in greater detail below.

In Plate 5 the depths to seismic Horizons A and B, as measured on Lines 13C, 15G, and 53B, are compared with the Bouguer gravity anomaly profiles taken from the results of the Lennis-Breaden gravity surveys. The point at which a surface anticline intersects Line 13C is also marked.

Lines 13C and 15G intersect what is probably the same anticlinal feature, which may be one of several running parallel to the surface structure and to the gravity grain. Line 53B intersects another anticlinal structure, which could be a parallel fold. The first of these anticlines runs along the axis of the Mount Samuel Gravity Low. It looks like an inclined fold with steeper eastern limb. A sharp gravity doublet coincides with the fold; the maximum occurs over the shallow limb and the minimum over the steeper limb. Within the core of this anticline all reflections are lost across a distance of five miles. Reflections on either side of the core indicate that the wall rocks may be upturned to depths of 20,000 feet or more. Piercing may have taken place to a large extent in this fold. Browne Nos. 1 and 2 were drilled on the crest of this anticline and struck limestone, shale, and gypsum at about the depth of Horizon A. This could be confirmation of the diapiric nature of the fold.

An inclined diapiric fold with an exposed core at about the depth of Horizon A provides a possible explanation of the gravity doublet effect, particularly if the shallow limb carries a cover of dense basalt.

Yowalga No. 2 was drilled on a more gradual and regular structure. There are indications of piercing near the crest of the anticline but only to a small extent.

Continuous velocity log in Yowalga No. 2 well

Schlumberger ran a sonic log in Yowalga No. 2 well. The results are summarised in Table 3.

## 4. OBJECTIVES

It was intended to conduct a reconnaissance seismic survey along an approximately east-west line from Giles Weather Station to Carnegie Homestead, using reflection and refraction techniques with the following objectives:

TABLE 3

Velocities measured by sonic log in Yowalga No. 2 well

| Age | Lithology | Depth (feet) | Velocity range (ft/s) |
|---|---|---|---|
| Mesozoic | Laterite, claystone, sandstone, siltstone. | 25 - 310 | 5000 - 10,000 |
| Lower Permian | Sandstone | 310 - 1335 | 8000 - 11,000 |
| Upper Proterozoic | Brick red arkosic sandstone | 1335 - 2390 | 9000 - 11,000 |
| Upper Proterozoic | Basalt | 2390 - 2775 | 14,000- 20,000 |
| Upper Proterozoic | Sandstone and shale with veins and fracture fillings of anhydrite and gypsum | 2775 - 2910 | 10,500- 15,000 |
| Upper Proterozoic | Dolomite with veins and fracture fillings of anhydrite and gypsum | 2910 - 2930 | 18,000- 23,000 |
| Upper Proterozoic | Shale, siltstone | 2930 - 3246 | 11,000- 12,000 |

1. To distinguish, by criteria involving velocity and structural indications such as unconformities, between the main sequences of rocks, more particularly Precambrian metamorphic, Upper Proterozoic, Palaeozoic, and Mesozoic.

2. To delineate regional structures if moderately deformed sediments were detected; more particularly to help determine directional trends of axes, faults, and regional dips.

3. To trace the tectonic history of any anticlinal feature discovered; more particularly to trace periods of deposition quiescence, movement, and erosion.

4. To indicate from seismic evidence where stratigraphic drilling may be carried out to produce significant information and to carry out some such drilling when the target was within the capabilities of the drilling equipment on the seismic party.

5. To carry out reflection and refraction traverses following the main rock sequences by seismic techniques.

## 5. PROGRAMME, GENERAL

It was proposed to record a number of short refraction traverses located or known outcropping formations at the eastern edge of, and to the east of, the main sedimentary area; this includes the traverse at Signpost and all traverses east of there (Plate 1). The purpose was to determine refractor velocities associated with known rock sequences as a means of later identifying main rock sequences within the sedimentary section and at its base.

The survey would then be continued west from Signpost carrying out refraction probes at about 30-mile intervals. It was hoped that it would be possible, by correlating refractor velocities from probe to probe, to measure the thickening of the sedimentary section above metamorphic basement and to distinguish between the main sequences within the sedimentary section (i.e. Proterozoic, Palaeozoic, and Mesozoic).

From Mount Charles westwards, short reflection traverses would be recorded over each refraction probe in order to:

(a) test the effectiveness of the reflection method for mapping structure in the area and

(b) assist in the interpretation of the refraction probes.

These reflection traverses would be extended to investigate structure, as required by the objectives and where practical.

Two short refraction traverses would be recorded west of Carnegie Homestead to measure refractor velocities on known Proterozoic sediments and on Precambrian metamorphic rocks, so that agreement might be checked with the velocities measured at the eastern edge of the basin.

It was thought important to see whether the metamorphic basement refractor could be followed across the basin and whether it could be distinguished from possible high velocity refractors within the sedimentary sequence so as to measure the thickness of the Proterozoic sediments.

It was intended to complete the survey in two parts - firstly westwards as far as Mount Beadell in 1961, and secondly from Mount Beadell to Carnegie in 1962.

## 6. PROGRAMME AND RESULTS, 1961.

### Proposed programme

During the first part of the programme in 1961, two months were to be spent as follows:

(1) At Mount Davies, South Australia, while travelling between Alice Springs and Giles, to record a refraction traverse on the Precambrian rocks (Musgrave Complex).

(2) At Giles, to record a refraction traverse on the Precambrian rocks.

(3) At Giles, to record a refraction traverse on the north side of the Rawlinson Range to determine velocities associated with the Upper Proterozoic Dean Quartzite.

(4) In the Giles area, if access could be gained to the Carnegie Range about 60 miles north of Giles, to record a refraction traverse on dolomite beds within the Upper Proterozoic Bitter Springs Formation and on the neighbouring Upper Proterozoic rocks.

(5) At Lake Christopher, about 60 miles west of Giles, where Permian glacial rocks crop out, to record a refraction traverse and so find the seismic velocity in this material, and in the underlying material. A geological sample was to be cored from a shot-hole.

(6) About 60 miles west of Lake Christopher, and near the Iragana Hills turn-off, to record a refraction depth probe which should penetrate the Mesozoic and Permian rocks and reach the underlying high-velocity material. A geological sample was to be cored from a shot-hole.

(7) At Sunday Hill, to record a refraction depth probe to reach Precambrian metamorphic or igneous basement beneath the Permian and Mesozoic rocks.

(8) At a suitable location just west of Signpost, to determine a refraction technique that would allow the Precambrian metamorphic basement and, if possible, the Permian to be followed westward towards Mount Charles, in such a way that the thickening of sediments above the basement could be estimated.

(9) If Upper Proterozoic rocks could be located just south of Mount Charles, to carry out a refraction depth probe. A geological sample was to be cored near Mount Charles.

(10) At about eight miles west of Mount Samuel, where the Permian is exposed, to record a reflection and refraction traverse. A geological sample was to be cored.

(11) Near trig point NMF 19, to record reflection and refraction probes on the Mesozoic rocks. A geological sample was to be cored at NMF 19, near the contact of Permian and Mesozoic outcrops.

(12) At Mount Beadell (NMF 20), to record reflection and refraction probes. According to known geology (Leslie, 1961) this might reveal Jurassic, Permian, and Upper Proterozoic sequences above Precambrian metamorphic basement. A geological sample was to be cored.

(13) If the general seismic picture warranted it, and if time permitted, to make further probes in the Mount Charles and Mount Beadell areas to obtain information about regional trends.

Programme carried out and results

The programme proposals outlined above were carried through with various degrees of completeness.

(1) to (3) The refraction traverses at Mount Davies, Giles, and the Rawlinson Range were completed as planned (Plate 25).

(4) Reasonably easy access to Carnegie Range could not be found. This traverse was therefore laid near Lake Hopkins where Upper Proterozoic rocks occur at shallow depth, but it seems likely that the material investigated (14,000 ft/s) was Carnegie Formation rather than dolomite from the Bitter Springs Formation as planned (Plate 25).

(5) The refraction traverse at Lake Christopher was completed as planned (Plate 26).

(6) The refraction depth probe at Iragana Hills turn-off was recorded as planned but the maximum velocity recorded was 14,350 ft/s at a maximum shot-to-geophone distance of 17,160 feet (Plate 27).

(7) The refraction depth probe at Sunday Hill was abandoned because no suitable track to Sunday Hill could be found.

(8) This proposal was only partly completed. A refractor of velocity 20,500 ft/s was recorded very close to the surface at Signpost (Plate 25).

(9) This proposal was modified in the field. Upper Proterozoic rocks were not identified with certainty just south of Mount Charles so the traverse was placed on the track at Mount Charles itself. The highest velocity measured by the refraction probe was 17,800 ft/s at a maximum shot-to-geophone distance of 9240 feet. The results from this probe have been included with results of the 1962 work in Plate 28. A short reflection traverse was recorded using single holes and six geophones, 22 feet apart, per trace. No reflections were pickable (Plate 15).

(10) The maximum velocity recorded in the refraction probe near Mount Samuel was 11,140 ft/s at a maximum shot-to-geophone distance of 13,200 feet. The results from this probe have been included with the results of the 1962 work in Plate 29. A short reflection traverse was recorded using single holes and six geophones, 22 feet apart, per trace. No reflections were pickable (Plate 16).

(11) The maximum velocity recorded in the refraction probe near NMF 19 was 10,100 ft/s at a maximum shot-to-geophone distance of 14,520 feet. The results from this probe have been included with the results of the 1962 work in Plate 30.
The shooting was intended to give sharp first breaks but the energy in the forward direction was considerably lower than in the reverse direction. This appears to be the reason why refractor $V_2$ may be picked in the reverse but not in the forward direction. Although there is energy present on the record from SP 808, it would appear to be a rapidly attenuating event and is not pickable.
A short reflection traverse was recorded using single holes and six geophones, 22 feet apart, per trace. Some very poor reflection alignments were obtained (Plate 17).

(12) At Mount Beadell, a refraction velocity of 10,450 ft/s gave way to a velocity of 17,300 ft/s at a critical distance of about 16,000 feet. The maximum shot-to-geophone distance used was 19,800 feet. The energy from the first of these refractors attenuated rapidly. The results from this probe have been included with the results of the 1962 work in Plate 31.
A short reflection traverse was recorded using single holes and shallow 9-hole diamond patterns with 6 geophones, 22 feet apart, per trace. A number of reflection alignments were recorded down to 1.5 seconds; at times greater than this there are many regularly spaced alignments whose significance was not known (Plate 20).

(13) This proposal was not attempted.

## 7. ADDITIONAL OBJECTIVES, 1962.

The objectives as stated in Chapter 4 were, of course, the objectives of the whole survey; however, the 1961 survey had posed certain detailed problems at Mount Beadell and east of there.

The attitudes of the 10,000 to 11,000 ft/s refractor at Mount Samuel and NMF 19 indicated the possible presence of an anticlinal axis under Lake Breaden. In order to develop a possible stratigraphic drilling location, it was required to know if a relatively thin section was present and whether this section was complete or truncated. An explicit objective of the continuation of the survey in 1962 was therefore:

(a) To seek confirmation of possible structure between Mount Samuel and NMF 19.

The results of the reflection traverses had on the whole been very poor; the exception was at Mount Beadell, where reflection quality was still not good. Only simple techniques has been used in the reflection shooting. The usefulness of the reflection method had not therefore been properly assessed as a means for delineating structure in the area. A further explicit objective of the 1962 survey was:

(b) To improve reflection sections at NMF 19 and Mount Beadell.

## 8. PROGRAMME AND RESULTS, 1962.

### Proposed programme

As stated in Chapter 6 the programme west to Mount Beadell was only partly completed in 1961; also, as stated in Chapter 7, additional objectives requiring further investigation had resulted from the 1961 survey.

In 1962, it was proposed to spend about 3 months carrying out the following programme:

1. At NMF 19 to complete the 1961 depth probe making every effort to record the 20,000 ft/s refractor.

2. At NMF 19 to make every effort to obtain reflections. To try to record a reflection section over the refraction probe and, if any significant dips were confirmed and a practical procedure established, to continue the reflection traverse an extra 5 miles up-dip.

3. Depending on the NMF 19 results, to complete the refraction probe at Mount Samuel at least to the 17,000 ft/s refractor and if practical to record a reflection section over the refraction probe.

4. To assess the above results in conjunction with gravity data and to decide whether recording of the 20,000-ft/s refractor at Mount Samuel and Mount Charles was warranted.

5. To obtain an improved reflection section at Mount Beadell over the refraction probe.

6. West of Mount Everard: to record a refraction probe to find the depths and attitudes of the Permian and the Proterozoic sediments and if possible also of the metamorphic or igneous basement; to record 5 miles of reflection traverse; to take a 5 to 10-ft core from the bottom of a shot-hole as a geological sample.

7. To find a track into Young Range from Mount Everard and to take a geological core from near NMF 22.

8. to 10. At each of three locations, west of NMF 23, between NMF 25 and NMF 27 (Fame Range), and west of NMF 27, to carry out programmes similar to that proposed near Mount Everard in item 6.

11. West of NMF 29: to record a refraction probe to test for Permian sediments, Proterozoic sediments, and Precambrian metamorphic rocks; if metamorphic basement is deep, to record 5 miles of reflection traverse; to take a core from the bottom of a shot-hole as a geological sample.

12. A little west of Carnegie where Proterozoic sediments should be shallow or outcropping: to record a refraction probe and to make all reasonable efforts to record the 20,000 ft/s refractor.

13. To check the Precambrian metamorphic refraction velocity west of Carnegie.

Programme carried out and results

General remarks. Items (1) to (5) of the proposed programme, at and east of Mount Beadell, occupied a large part of the time available, with the result that only a relatively small amount of work was done west of Mount Everard.

A short reflection traverse was recorded on the straight road running between Mount Everard and NMF 23 in partial compliance with Items (6) and (8).

Geological cores were taken from deep holes in the Young Range in compliance with Item (7), and near NMF 23 in partial compliance with Item (8).

When the results became available from the 1962 helicopter gravity survey (Lonsdale and Flavelle, 1963) it appeared that the area where a greater thickness of sedimentary section could be expected, and therefore the area of greater interest from the point of view of oil exploration, was in the Herbert Gravity Sub-Depression, to the north of the road to Carnegie Homestead, along which it had been intended to carry out the survey - Items (9) to (11). It was therefore decided to shift the survey to the north and to carry out a refraction traverse in the vicinity of Lake Keene in partial fulfilment of these items.

Items (12) and (13) were not attempted.

Surveying. The surveyors were able to tie into bench-marks every five miles along the road; these had been put in by a survey party from the Department of the Interior in 1961 for the regional gravity survey carried out in 1962.

The Lake Keene traverse levels were tied into Gravity Station 200/1962.

Some of the traverses occupied in 1962 had already been occupied in 1961; where this was so 1320-ft spreads, with 110 feet between geophone group centres, were used as in 1961 (NMF 19, Mount Beadell, and Mount Charles). New cables for 1800-ft spreads, with 150 feet between geophone group centres, were carried on the party in 1962 and, where a new traverse was occupied (Mount Samuel, Mount Everard, and Lake Keene), 1800-ft spreads were used.

Drilling. Three drilling rigs (one Failing and two Careys) were operated, except for occasional short periods when water scarcity made it necessary to stop the Failing, which did not have air drilling facilities. A new Mayhew 1000 rig, which joined the party on 20th October, suffered various teething troubles and, although running in of the machine and the experience gained with it were valuable, it drilled only 2750 feet of shot-hole footage. Any excess drilling power was used for drilling geological core holes, and two core holes having depths of 273 and 431 feet were drilled with the Failing.

The two Carey rigs drilled 86% of the shot-hole footage during the survey. On the NMF 19 traverse and on parts of the Mount Beadell traverse the small gravel near the surface tends to fall in shot-holes drilled with air. Augers were used largely for both shallow and deep holes, down to 150 feet. The resulting water economy was very valuable. Occasional thin hard bands were encountered. Hard material was encountered sporadically on the surface at Mount Everard, and this would vary over one shot-hole pattern. Most of the shallow holes at Mount Beadell and Mount Everard were drilled with air. Drilling at Lake Keene was almost entirely with augers.

Weathered layer. The three reflection traverses carried out during the 1962 survey (NMF 19, Mount Beadell, and Mount Everard) were situated on areas of Cretaceous outcrop (Leslie's third topographic zone). As might have been expected from the geology, i.e. Tertiary deposits of bedded white chalcedony, marly chacedonic breccia, and sandy siliceous limestone (travertinous), high velocity stringers were encountered within the first 150 feet of the surface; correspondingly, occasional hard bands were noticed in the drilling.

When weathering shots were recorded at SP 820 and SP 821 on Traverse NMF 19, a refractor was recorded having a velocity of 8000 ft/s at a depth of 20 feet. There was previous evidence of the presence of stringers and it was decided to record an uphole shoot at SP 821 on a spread of 24 single geophones at 20-ft intervals (Meissner, 1961). The wave-front diagram obtained is shown in Plate 6. High velocity layers are indicated at depths of 20 and 40 feet.

A study of the results of the uphole shoot recorded at SP 812 in 1961 made it appear that there might be a high velocity layer at a depth of 110 feet. A Meissner uphole shoot was recorded and the results indicate high velocity layers at depths of 12 and 110 feet (Plate 6).

Meissner uphole shoots were also recorded at SP 804 and SP 805, where high velocity layers are indicated at 15, 25, and 110 feet and 20, 30, and 70 to 100 feet, respectively (Plate 6).

These uphole shoots demonstrate the erratic and sporadic nature of the high velocity stringers that occur in the weathered layer on Traverse NMF 19. In such an area the velocities in the weathering and sub-weathering layers and the depth of their interface may only be determined by uphole shooting.

The high velocity layer at a depth of about 110 feet seemed to constitute the base of the weathered layer and seemed to be fairly continuous; it was also the source of the first breaks with a deep shot (about 110 feet). With this in mind a deep shot was recorded at every shot-point from SP 805 to SP 821, where a deep shot had not already been recorded. Some of the shots were not sufficiently deep because of difficulty in drilling deep holes and in getting holes to remain open.

The present weathering corrections on Traverse NMF 19 have been computed using the uphole shoots at SP 805, SP 812 and SP 821 as basis and interpolating by use of drill logs.

At Mount Beadell a deep shot was recorded at each of the reflection shot-points. The thickness of the weathered layer was computed from an interpretation of the shallow refractors (Plate 31).

At Mount Everard velocities of the order of 13,000 ft/s are recorded from 6 feet below the surface (corresponding to hard material encountered at the surface by the drills). Only one deep shot was recorded at Mount Everard; this shows an average velocity of 3000 ft/s down to 72 feet.

An analysis of the uphole times over all traverses shows that in general the low velocity (3000 ft/s) surface layer is 100 feet or more thick. It would appear that most shots throughout the survey were fired in the weathering. At SP 805 on Traverse NMF 19 a thick layer of high velocity material is seen to occur below 80 feet (Plate 6). It seems likely that a similar region of high velocity material occurs at shallower depth in the centre of the Mount Beadell traverse (Plate 31).

In general the weathering corrections applied to the various refraction probes are not considered reliable. Variations of the order of 10 milliseconds occur at the same position in the arrivals from different refractors. For example an irregularity occurs just east of SP 310 at Lake Keene corresponding to an obvious variation in surface elevation. Where the variation was obvious, smoothing was carried out prior to the depth computation.

Refraction method. In the extensions to the refraction probes at NMF 19, Mount Beadell, Mount Charles, and Mount Samuel (Proposed Programme Items 1, 3, and 4) large shot-to-geophone distances and large charges were used (Plates 28, 29, 30, and 31). Because of the remoteness of the area and the limited time available it was not practical to increase the shot-to-geophone distance continuously, as would have been desirable. Only a few shots were recorded in each probe and increments of the order of 25,000 feet were made to the shot-to-geophone distances. The method was sufficient to satisfy the primary requirements of the survey but did entail extra difficulties and doubts in the interpretations of the probes, as will be noted later.

These four refraction probes were situated largely in scrub consisting mainly of small trees from 10 to 20 feet high. Light winds blew frequently during daylight hours and the resulting noise background was high. A quiet period, free from wind, occurred regularly just after dawn, and some long distance recordings were made during this period.

Electrical storms accompanied by showers were quite frequent and these prevented the transmission of the time-break by radio on several occasions.

It should be noticed that, although there are shot-point numbers common to NMF 19 and Mount Beadell traverses, the shot-points do not coincide.

The charge and depth of shot for each refraction recording is given in the appropriate plate. Geophex was used for all shots except the farthest ones at Mount Beadell, SP 672 and SP 774, where a mixture of Nitrolite and diesoline primed with Geophex was used.

Magnetic recordings were made of most shots. In 1962 all recordings were made on fixed gain.

The computation and presentation of the refraction results are largely as in Vale and Smith (1961). In the depth plots, the rays at the shot-points have been taken to a depth proportional to the shot-point intercept. However, the division of total intercept between geophone and shot-point is largely arbitrary, except on some shallow refractors and at Lake Keene, where continuous two-way coverage was recorded between shot-point and geophone. The average velocity of the overburden above a particular refractor has been taken as constant over any one probe.

NMF 19 refraction traverse. The refraction shooting on Traverse NMF 19 (Plate 30) was started with a shot to furthest geophone distance increased, from the 14,520 feet reached in 1961, to 36,960 feet (SP 792 and SP 834). The refraction velocity measured was about 17,000 ft/s similar to that obtained in the Mount Beadell refraction probe in 1961.

Attempts were made to record the 20,000-ft/s velocity as a first event by further increasing the shot-to-geophone distance to 50,160 feet (SP 782 and SP 844) and then to 77,880 feet (SP 762 and SP 864). From the shot at SP 864 a strong second event was recorded showing a velocity greater than 20,000 ft/s. It was computed that it would require a shot-to-geophone distance of about 150,000 feet to record this refractor as a first event. Because this event was only recorded from one direction and because of the uncertainties involved in the interpretation of second events, it was decided to concentrate further effort to record the 20,000-ft/s refractor at Mount Beadell, where gravity results indicated that it might be shallower.

The refractor $V_3$ is characterised by arrivals having long periods, mostly about 135 milliseconds. The arrivals from the more distant shots were emergent but energetic. With the records from the most distant shots there is some doubt as to which phase was picked.

The event recorded from SP 800 with an apparent velocity of 20,800 ft/s is interfered by a slower event on the nearer traces. Although there is plenty of energy at this distance it would appear to be attenuated fairly rapidly. The event shows a period of 50 milliseconds.

Mount Beadell refraction traverse (Plate 31). The distance from the shot to the furthest geophone was increased, firstly by 7920 feet, from the maximum of 19,800 feet (SP 702 and SP 724) used in 1961 to 27,720 feet (SP 698 and SP 728), to record $V_3$ as a first event over the whole spread from both directions and to obtain greater two-way coverage on the $V_3$ refractor.

It was attempted to record the 20,000-ft/s refractor by increasing the distance from the shot to the furthest geophone by 36,960 feet to 64, 680 feet (SP 672 and SP 754). $V_3$ was still recorded as a first event.

Towards the end of the survey, after the refraction work at Mount Charles and Mount Samuel, a further two shots (SP 652 and SP 774) were recorded with a distance from the shot to the furthest geophone increased by 26,400 feet to 91,080 feet. A higher velocity refractor was recorded. The arrivals from these furthest shots showed good energy but were emergent and there is a slight doubt as to which phase was picked.

Mount Charles refraction traverse (Plate 28). The 20,000-ft/s refractor had not been recorded at Mount Beadell from shot-points 672 and 754. It was thought that this refractor might be recorded more easily at Mount Charles with a small amount of shooting. The eastern dip on the 17,800-ft/s refractor, measured in 1961 (Watson, 1963), was surprising and it was thought that the apparent velocity of 18,350 ft/s might be a down-dip metamorphic velocity. Further measurement at Mount Charles might remove the necessity for more shooting at Mount Samuel, where access was difficult.

Two shots (SP 1005 and SP 1021) were recorded with distances to the furthest geophones equal to 14,520 feet, and two shots (SP 971 and SP 1055) were recorded with distances to the furthest geophones equal to 63,360 feet. Other than this, shots were recorded from 1320 feet from both ends of each spread for near-surface control.

The interpretation shows a 17,000-ft/s refractor with fairly flat east-west dip at a depth just less than 2000 feet. Between shot-points 1013 and 1016 the refractor velocity increases to 19,950 ft/s.

Mount Samuel refraction traverse (Plate 29). At NMF 19, the western dip of the 10,100 ft/s refractor, as measured in 1961, was not confirmed, and dips appeared to be fairly flat throughout the section. It was therefore decided to limit the work at Mount Samuel to a quick extension of the refraction probe to measure the approximate depth and attitude of the 17,000 ft/s refractor.

Extensions of the Mount Samuel traverse in its original position would have involved difficult problems of access. A new traverse was surveyed, offset at an angle of 12° 46' from the 1961 traverse, so that shot-points 900A and 955A would be within easy access of the road. Shots were recorded from these two shot-points with a distance from shot to furthest geophone of 61,200 feet in each case. The 17,000-ft/s refractor was indicated as fairly flat-lying at about the same depth as at NMF 19. The only other shots to be recorded were at the centre and each end of the two spreads for near-surface control.

Lake Keene refraction traverse (Plate 32). Access was gained to the area by leaving the road east of Fame Range and driving along the foot of the range through open spinifex and light scrub; further north, sand dune country was crossed by following the line of the dunes in a north-westerly direction. The total distance of the traverse from the road was about 40 miles.

The layout of this probe was much different from the others. Continuous recording was carried out over a distance of four 7200-ft spreads. Shots were recorded on each spread from the centre and ends and then every 7200 feet off both ends to a maximum shot-to-geophone distance of 43,650 feet.

The control obtained in the interpretation was improved considerably, as two-way coverage between shot-point and geophone was obtained on all refractors.

Reflection method. As stated in Chapter 7, an explicit objective of the 1962 survey was to improve reflection quality at NMF 19 and Mount Beadell. It was required to get the best results with the equipment available. 24 geophones per trace was the maximum number that could be used for a spread of 24 traces.

The programme was started by carrying out a short noise test. It was considered that the main question to be answered by the noise test was whether it would be better:

(1) to increase the number of geophones in line to obtain greater cancellation of the organised noise along the traverse or

(2) to extend the pattern at right angles to the traverse so as to cancel transverse organised noise.

The cancellation of random noise would be increased by both arrangements, probably more by the latter because of the increased average spacing. It was to be borne in mind that an increased cancellation of longitudinal organised noise (and random noise) could be obtained by subsequent mixing or compositing.

In a noise test recorded with single geophones, noise is recorded at large amplitude which would be reduced considerably by the basic in-line geophone group (six geophones, 22 feet apart) which had been used in 1961. It was considered that the information required for the solution of the problem as stated above was what noise remained after the application of filtering by the basic group. It was therefore decided to carry out a noise test recording with the basic group.

Noise Test at SP 813 on Traverse NMF 19. The layout used in the noise test is shown in Plate 8. Shallow (15-ft) and deep (85-ft) shots were recorded on all three longitudinal spreads and both cross-spreads. All shots were recorded using A.G.C. and filter settings as for a reflection record.

The results of the noise test are shown in variable-area cross-section form in Plate 8. Noise trains have been picked on these sections, and apparent velocities and average periods were measured. The wave-number values corresponding to the mean spectral frequency of each wave train was then computed. The noise trains have been plotted in Plate 9 with the above parameters marked.

Shot-hole and geophone pattern comparisons on Traverse NMF 19. The noise test showed that considerable organised transverse noise was present. On the basis of the noise test it was decided to compare 24 geophones in a square pattern against the basic geophone group in twin parallel spreads between SP 814 and SP 815. Traces 1 to 12 had 6 geophones per trace and traces 13 to 24 had 24 geophones per trace.

The following shot-hole patterns were recorded on the comparison spread (see Plate 10)

(a) Diamond pattern of 36 shallow holes

(b) In-line pattern of 7 deep holes

(c) In-line pattern of 3 deep holes

The first two patterns were chosen as being approximately equal and of maximum effort. In fact the 7 deep holes took longer to drill than the 36 shallow holes.

The results of the comparison spread showed that an improvement in signal-to-noise ratio was obtained by going from the six to the 24 geophone pattern and that a further improvement was obtained by mixing. It was therefore decided to continue the use of the 24 geophone square pattern.

The 36-hole diamond pattern gave only a poor quality record and therefore a smaller diamond pattern was not tried.

The 36-hole diamond pattern and the 7-hole in-line pattern gave records of comparable quality but different character.

Reflection Traverse NMF 19. In order to decide between the 36-hole diamond pattern and the 7-hole in-line pattern, both were used in recording along two miles of traverse. The results of this recording are shown in Plates 18 and 19. The 36-hole pattern gave the more continuous reflections.

Because of the slowness of the method evolved, the reflection programme at NMF 19 was curtailed and only the 2 miles of reflection traverse was recorded.

Reflections were picked on the recordings from both the 36-hole and the 7-hole patterns and are plotted in Plate 23.

Shot-hole and geophone pattern comparisons on Mount Everard Traverse. A short test of the effectiveness of the reflection method was made on the Mount Everard Traverse at SP 613. The square pattern of 24 geophones was compared against the basic group of 6 geophones in twin parallel spreads between SP 612 and SP 613. A single deep shot and a 36-hole diamond pattern of shallow shots were recorded on this comparison spread.

The results of the comparison recordings are shown in variable-area cross-section form in Plate 11.

Mount Everard Reflection Traverse. The improvement in record quality obtained from the 24 geophone group in the comparison recordings was thought sufficient to warrant its use on this traverse.

The 36 shallow holes in a diamond pattern gave a record quality comparable to that at NMF 19.

The method that had given the best results on the NMF 19 traverse was therefore used to record a short section on the Mount Everard traverse. The results are presented in variable-area cross-section form in Plate 22. Reflections were picked and are plotted in Plate 23.

It should be noted that the spread length used at Mount Everard was 1800 feet as against 1320 feet used elsewhere.

Mount Beadell reflection traverse. As already stated in Chapter 8 the surface geology in the vicinities of the NMF 19, Mount Everard, and Mount Beadell reflection traverses is similar. At Mount Beadell it was therefore decided to start straight away using a diamond pattern of 36 shallow holes and a square pattern of 24 geophones, which had had a certain amount of success at NMF 19 and Mount Everard. Records from the 1961 survey with visible reflections would provide a comparison from which improvement could be gauged.

A reflection section $2\frac{3}{4}$ miles long was shot. The results are presented in variable-area cross-section form in Plate 21. Reflections were picked and are plotted in Plate 23.

Expanded spread velocity shoot. The best reflections of the survey were recorded at SP 714 on the Mount Beadell traverse. These were good enough to warrant an expanded spread velocity shoot.

The results of this velocity shoot are presented in variable-area form in Plate 12. It will be seen that the layout was such that reflections would be recorded from the same 1320 feet of subsurface for each of the five shots. Spread length and shot-hole and geophone arrays were as used for the reflection traverse. The maximum shot-to-geophone distance was 6600 feet.

The principal reflections were picked and lettered from A to G. Time ties were excellent. A $t^2$:$x^2$ plot was constructed and is presented in Plate 13.

Reflections obtained at Lake Keene. Recording at Lake Keene was carried out primarily with the intention of obtaining information by the refraction method. Single shots were recorded on spreads 7200 feet long. The trace spacing was 300 feet and there were 4 geophones per trace extended at right angles to the line of the traverse at 22-ft intervals. Shot-to-geophone distances ranged from 0 to 50,000 feet. Recordings were made with fixed gain and filters either 0-30K or 0-40K. The high-cut filter was used to cut down wind noise. All shots were recorded on magnetic tape and it was hoped that reflections might be recorded.

In fact reflections were recorded from SP 297 and SP 301 at shot-to-geophone distances between 15,000 and 44,000 feet. The results obtained from SP 297 are presented in variable-area cross-section form in Plate 24. Both an uncorrected and a dynamically corrected section are shown (see Chapter 9).

Core holes. A geological core hole was drilled about half a mile to the north of Charles Knob in the Young Range. Access was gained by travelling thirteen miles north along a track which leaves the road near gravity marker 82 - 26 five miles west of Mount Everard. The hole was cored from 268 to 273 feet and 2 feet 6 inches of core was recovered. The core was dated as Cretaceous from Aptain marine plant spores found by R. Evans (Wells, 1963).

A geological core hole was drilled beside the road about three miles south-west of NMF 23. The hole was cored from 422 to 431 feet and 9 feet of core was recovered. Permian plant spores, found in the core by R. Evans, indicate that the rock is the time equivalent of the Grant Formation in the Fitzroy Basin (Wells, 1963).

## 9. DISCUSSION OF RESULTS

### Refraction

The seismic energy is attenuated rapidly in the 10,700-ft/s refractor at NMF 19 and in the 11,000-ft/s refractor at Mount Beadell. It also appears to be attenuated fairly rapidly on the 10,000-ft/s refractor at NMF 19. There is insufficient information to tell much about the rate of attenuation in the 11,000-ft/s refractor at Mount

Samuel. These refractors have been correlated as Permian (see Chapter 10). These indications of thin higher velocity layers within the Permian section are in agreement with the sonic log in Yowalga No. 2, where a layer 100 feet thick at the top of the Permian section has a velocity of 10,000 ft/s, followed in sequences by 100 feet at about 7000ft/s, 100 feet at about 10,500 ft/s and 300 feet at about 8500ft/s.

At Mount Charles the first arrivals from the two most distant shots, SP 971 and SP 1055, consist of two cycles at low amplitude followed by two cycles increased in amplitude by a factor of four. All phases have the same slope. The period of the lower amplitude event is from 50 to 80 milliseconds and the period of the large amplitude wave is from 90 to 100 milliseconds. Arrivals from the 17,000-ft/s refractor recorded at shorter distance, although complex, have not the same character. Only one refractor has been interpreted. At Mount Samuel the arrivals from the two most distant shots, SP 900A and SP 955A, are similar to those at Mount Charles in that they consist of an initial two cycles at low amplitude followed by two cycles at about four times this amplitude and the periods are about the same as at Mount Charles. However, the larger amplitude phases have slopes different from those of the first arrivals and two refractors have been interpreted, having velocities of 17,000 ft/s and 18,200 ft/s. At NMF 19, the first arrivals from the 16,800-ft/s refractor are mostly emergent and show evidence of more rapid attenuation. The period is mostly about 135 milliseconds. The arrivals from SP 782 and SP 834 are complex. At Mount Beadell the arrivals from the 16,600-ft/s refractor are fairly definite except for those recorded from SP 754, where the energy is low. Periods range from 60 to 100 milliseconds. The closer recordings show some complexity.

The 16,600 to 17,000-ft/s refraction appears to be a rather complex event. There is insufficient information on any probe to show the full nature of the complexity. It is known that this refraction probably takes place at an angular unconformity and that the rocks below the interface contain layers with considerable variation in velocity (Chapter 10).

At NMF 19 the second event from SP 864, which shows a velocity of approximately 20,500 ft/s, is very strong. The period is about 130 milliseconds. At Mount Beadell the first events from the two most distant shots, SP 652 and SP 774, show a velocity of about 20,500 ft/s and have periods of about 140 milliseconds. The events are definite and fairly strong but there are indications of complexity. On the record from SP 652 the 20,500-ft/s event appears to be interfered by the 16,600-ft/s event; this is not surprising, as the shot-to-geophone distance must be just greater than the critical distance.

Reflection

Noise test. The noise test described in Chapter 8 consisted of both longitudinal and transverse recordings of both deep and shallow shots (Plates 8 and 9). With the deep shots, not a great many line-ups of coherent noise remained on the longitudinal noise test; presumably these had been fairly well filtered by the 6-geophone group used in the test. Transverse noise line-ups came through fairly strongly. With the shallow shots the longitudinal noise line-ups came through much more strongly and so did the transverse line-ups.

The most obvious difference between the records from the deep and shallow shots is the lower frequency character of the records from the shallow shots. A further difference is that a wider wave-number spectrum is apparent in the deeper recordings. This may be because of the lower overall noise levels. The histograms plotted at the bottom of Plate 9 show both of these effects.

A very noticeable feature of the transverse recordings is that most of the events have approximately the same velocity. These velocities are low, mostly between 800 and 1000 ft/s. This velocity does not appear on the longitudinal recordings and is most likely a resultant apparent velocity.

The histogram for the shallow longitudinal noise recording shows three sharp peaks. These correspond to:

(1) First arrivals and events throughout the record with velocities from 5000 to 10,000 ft/s.

(2) Surface waves spreading from the shot with velocities of 1720 and 1900 ft/s.

(3) Air waves with velocity 1130 ft/s.

Because of the smaller charges, 2/3 and $2\frac{1}{2}$ lb as against 5 to 15 lb, and the deeper holes, 13 feet as against 2 to 6 feet, the shallow holes did not blow during the reflection shooting and the air wave was not obtained.

The histogram for the deep longitudinal noise recording shows most of the noise to have a wave number below 6 per 1000 feet. Apparent velocities range from 4900 to 23,600 ft/s. A separate small peak represents the residue of the surface wave line-ups and shows a velocity of 2240 ft/s.

During the Yowalga seismic survey the 'Thumper' produced two strong noise events with velocities of 1600 and 3400 ft/s. Similar velocities were recorded by the 'Vibroseis' during the Babbagoola survey on Line 1. The surface wave velocity of 1600 ft/s agrees fairly well with the 1720-ft/s measured at NMF 19 with the shallow shots. The event showing a velocity of 3400 ft/s may be a P wave refracted in a high velocity layer within the weathering and may have no exact equivalent at NMF 19, where events in the same part of the recording show velocities of about 8000 ft/s, which is similar to the first-break velocity.

Geophone and shot-hole pattern comparisons. The comparisons are described in Chapter 8. The main comparisons were made between SP 814 and SP 815 on traverse NMF 19 following the noise test (Plate 10).

These tests show the improvement obtained by changing from 6 geophones in line to 24 geophones in a square pattern. As might be expected, since the diamond hole-pattern cancels transverse noise, this improvement is in some cases more marked with the in-line hole patterns (attention is drawn to the event at 2.37 seconds).

An improvement in reflection quality is seen to be obtained by mixing.

On such a small sample it is difficult to decide between the 36-hole diamond and the 7-hole in-line patterns. The decision is made particularly difficult because of the difference in frequency content in the records from the deep and shallow shots. However, comparison of the sections in Plates 18 and 19 shows greater reflection continuity to be obtained with the diamond pattern except perhaps in the shallower section at times less than 0.5 second.

The wave-number filter characteristics of the various patterns used are shown in Plate 7. Comparison of these against the histograms in Plate 9 will give some idea of the effectiveness of the patterns.

The sideways extension of the geophone pattern was limited to some extent by the type of jumper available. These had six entries at 22-foot intervals. The transverse response curve was not computed in full before use, only the zeros were computed. The curve has two rather unfortunate maxima. It is now thought that four strings of geophones at 22-ft intervals would have been far better than the arrangement used. The transverse noise has sufficiently high wave-numbers.

The comparisons made on the Mount Everard traverse (Plate 11) again show the improvement obtained by changing from 6 geophones in line to 24 geophones in a square pattern. The 36-hole diamond pattern again proved fairly effective and the single deep hole proved ineffective. The single deep hole had been tried in case reflections should prove easier to obtain on this traverse and also for up-hole purposes.

The expanded spread velocity shoot at Mount Beadell (Plate 12) shows what line-ups of longitudinal noise remain after filtering with the shot-hole and geophone patterns used in the reflection shooting, i.e. a 36-hole diamond pattern and 24 geophones in a square pattern. The most evident line-ups of residual noise have a velocity of 7000 to 8000 ft/s (wave number = 3). The mixed sections demonstrate the removal of this noise by mixing.

## Reflection sections

In 1961 no reflections could be picked on the reflection sections from Mount Charles, Mount Samuel, and NMF 19 (Plates 15, 16, 17). Fair reflections were obtained on the Mount Beadell traverse (Plate 20).

In 1962, by making a large increase in effort, fair reflections were obtained at NMF 19 (Plate 19). The same method obtained similar quality reflections at Mount Everard (Plate 22) and improved the reflection section at Mount Beadell (Plate 21).

Plentiful reflections are seen below 0.9 second. Most of these reflections have the appearance of being primary, e.g. between SP 711 and SP 714 at Mount Beadell. Occasionally this reflected energy runs together to give the appearance of an almost continuous wave, e.g. SP 815 at NMF 19. The interpretation of the expanded-spread velocity shoot (Plate 13) makes it appear as though the event at 1.542 seconds might be a multiple, but the picking of the reflection on the most distant traces is doubtful because of interference.

In 1961, energy was rather low at Mount Beadell with a single charge of 10 lb, 80 feet deep, and with 9 x $2\frac{1}{2}$ lb, 6 feet deep, in a diamond pattern. In 1962, the energy over the same part of the Mount Beadell traverse was sufficient, with 36 x 2/3 lb, 13 feet deep, and recorded with 24 geophones in place of 6. However, energy was still low at SP 715, SP 719, and SP 720. The energy on the central part of the NMF 19 traverse was low. At Mount Everard 36 x $2\frac{1}{2}$ lb was used and the energy was sufficient.

Comparison with Hunt Oil Company reflection traverses. As already noted in Chapter 8, the traverses at NMF 19, Mount Beadell, and Mount Everard were situated in areas of Cretaceous outcrop. All of the Hunt Oil Company reflection traverses in the Babbagoola, Warburton, and Yowalga seismic surveys were recorded in similar areas. Both the BMR traverses and the Hunt Oil Company Yowalga survey traverses were fairly widely scattered in the type area, and in each case fairly uniform record quality was obtained. It would therefore appear that although no common traverse was recorded, general comparisons are justified.

The method which has had the most widespread testing in the area is the 'Thumper' in a six-fold C.D.P. stack. This method has been found to be successful over most of the Yowalga survey area in mapping Horizon A and to a lesser extent deeper structure.

From the limited comparison available, indications are that the 'Vibroseis' with an approximately equal effort should give about an equal quality record (see Chapter 3).

On the NMF 19, Mount Beadell, and Mount Everard reflection traverses a shot-hole technique using large two-dimensional patterns of geophones and of shallow holes gave records of approximately equal quality to the 'Thumper'. While there was no outstanding event which could be easily correlated with Horizon A, the deeper information was better than the average quality obtained by the 'Thumper'; the shallower information was also better. It must be assumed that the reflecting conditions at Horizon A in the vicinity of the BMR traverses are different from those over the greater part of the Yowalga survey area.

The 'Thumper' section has clearly resolvable information to the bottom of the 3-second section. Horizon A is a strong continuous event, usually a two and a half cycle pulse with a period from 55 to 65 milliseconds. Deeper events are not everywhere continuous but they are sufficiently so to show deeper structure over most of the area. The periods of the reflected events range from 50 to 70 milliseconds.

The 'Vibroseis' section probably contains all the information present in the 'Thumper' section (see Chapter 3) but conflicting dips on the composited sections tend to destroy the resolution. The vibrator frequency sweep was 14 to 40 c/s and the periods of most of the reflected events are between 40 and 50 milliseconds.

Reflections with good resolution and fair continuity occur to the bottom of the 3.6-second sections at NMF 19, Mount Beadell, and Mount Everard (Plates 19, 21, and 22). The frequency content of the shot-hole sections depends on the depth of hole, as discussed for the noise test (Chapter 9). However, this effect is not so marked for reflected events (cf. plates 18 and 19). The periods of the reflected events lie mostly in the range 30 to 40 milliseconds. The resolution and character of events is probably better than in the sections obtained by the surface input methods. In the best quality records, for instance SP 711 to SP 714 at Mount Beadell, there is a certain amount of interference in the deeper section between events with slightly different dips. A certain amount of similar interference is present on the 'Thumper' sections but the primary events are strong enough to overcome it in a long section. However, this interference may point to the desirability of a C.D.P. method for multiple suppression. With a shot-hole method this could take the form of a six-fold C.D.P. stack using a diamond pattern of nine shallow holes.

Reflections obtained at Lake Keene. In Plate 24 the strongest reflections occur in a window between refracted events with velocities of about 6200 and 9000 ft/s. Reflections are present to the bottom of the section at 5.7 seconds, but events deeper than the strongest reflection at something over four seconds are very weak and could possibly be multiples .

A $t^2:x^2$ plot of the strongest reflection gives an apparent velocity of 22,400 ft/s and a centre time of 4.2 seconds. This velocity is too high to be compatible with the velocities that have been measured in the area (see Chapter 10). It appears that the reflecting horizon must dip to the west.

To determine dynamic corrections, the interval velocity was taken as 13,600 ft/s to a depth of 4,500 feet with a constant velocity of 19,000 ft/s below this. It was found difficult to produce a dynamically corrected section and the dynamic corrections equivalent to a centre time of 4.0 seconds were applied as static corrections.

Reflection alignments are also visible on records from SP 301 and SP 305. Magnetic recordings from other shots with the necessary offset are not of sufficient duration. It is not known whether the method is of general application in mapping deep reflectors in the area.

## 10. GEOLOGICAL INTERPRETATION

This section is discussed in the following order: correlation of refraction velocities; correlation of reflection sections; indications of structure.

TABLE 4

Correlation of velocity with age and type of rock.

| Age of rocks | Type of rocks | Sonic log Yowalga No.2 (ft/s) | Outcrop refraction probes | | Correlations in unknown section | |
|---|---|---|---|---|---|---|
| | | | Location | Velocity (ft/s) | Traverse | Velocity (ft/s) |
| Precambrian (undifferentiated) | Metamorphic and igneous | | Mount Davies | 19,850 6050 | NMF 19 | 20,500 * 6248 |
| | | | Giles | 18,900 5760 | Mount Beadell | 20,500 |
| | | | Signpost | 20,500 6248 | | |
| Upper Proterozoic | Volcanics - Basalt | 4267 6096<br>14,000 - 20,000 | | | Lake Keene | 16,050 4892 |
| | Quartzite | | Rawlinson Range | 16,100 4907 | | |
| | | | Lake Christopher | 16,010 4879 | | |
| | Limestone & Dolomite | 5486 7010<br>13,000 - 23,000 (Dolomite) | Rodinga (Amadeus Basin) | 18,900 5760 | Mount Charles | 19,950 6080 |
| | | | | | Mount Samuel | 18,200 5547 |
| | | | | | NMF 19 | 20,800 * 6339 |
| | | | | | Lake Keene | 5888 6013<br>19,320 - 19,750 |
| | Sandstone & Shale | 3200 4572<br>10,500 - 15,000 | Lake Hopkins | 14,000 4267 (Probably Carnegie Formation) | Mount Charles | 17,000 5181 |
| | | | | | Mount Samuel | 17,000 [illegible] |
| | | | | | NMF 19 | 16,800 5120 |
| | | | | | Mount Beadell | 16,600 5060 |
| | | | | | Lake Keene | 16,350 4983 |
| | Shale & siltstone | 3353 3657<br>11,000 - 12,000 | | | | |
| | Brick red arkosic sandstone | 2741 3353<br>9,000 - 11,000 | | | NMF 19 | 11,600 3536 |
| Lower Permian | Sandstone | 2438 3353<br>8,000 - 11,000 | Lake Christopher | 11,070 3374 | Mount Samuel | 11,000 3353 |
| | | | Lake Keene | 9,000 2743 | NMF 19 | 10,000 3048 |
| | | | | 10,600 3230 | | 11,000 3353 |
| | | | Iragana Turn-off | 8,950 2727 | Mount Beadell | 10,700 3261 |
| Mesozoic | Sandstone, siltstone, claystone and porcellanite | 1524 3048<br>5,000 - 10,000 | Mount Samuel | 8,900 2712 | Mount Charles | 8,800 2682 |
| | | | NMF 19 | 2286 2743<br>7,500 - 9,000 | | 10,250 3124 |
| | | | Mount Beadell | 1980 2590<br>6,500 - 8,500 | | |
| | | | Iragana Turn-off | 6,000 1829 | | |

NOTE: * Apparent velocity measured in only one direction.

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The correlation of refraction velocities with age and type of rock as derived below are shown in Table 4.

The overall interpretation is presented in cross-section form in Plate 4. The cross-section is made along the line of the traverses; directions and various surface features are indicated.

The Bouguer gravity anomaly along the line of the cross-section is shown for comparison. As already pointed out in Chapters 3 and 8 the first part of the survey from Signpost to Mount Beadell crosses the Mount Samuel Gravity Low and the Lake Keene traverse ~~traverse~~ is in the Herbert Gravity Sub-Depression. The intermediate Mount Everard traverse lies on the south-eastern end of the Madley Gravity Swell.

Correlation of velocity with age and type of rock

As already mentioned in Chapter 5, the refraction probes made at Signpost and east of there were intended to produce diagnostic velocities for later identification of the unknown rock sequences to the west. These probes had been sited near known outcrops. The velocities measured are tabulated in column 5 of Table 4 against the age and type of the outcropping rock in columns 1 and 2. Some velocities measured in these probes have been omitted from the table because of doubt as to the source rock. However, some other velocity measurements in known rocks have been included in column 5.

The 9,500-ft/s refractor at Lake Christopher has been omitted. It is within a few feet of the surface and the transmitted energy is attenuated rapidly. It probably corresponds to a high velocity stringer in the weathered layer, cf. Chapter 8.

The 16,010-ft/s refractor at Lake Christopher has been included in column 5 against the Upper Proterozoic Dean Quartzite. Outcrops of this formation occur over an area a few miles east of the traverse.

The 14,350-ft/s refractor at Iragana turn-off has been omitted. The nearest outcrops of Upper Proterozoic or Lower Palaeozoic age are at the Iragana Hills.

The 14,000-ft/s velocity measured at Lake Hopkins probably originates in the Carnegie Formation. Outcrops of the Carnegie Formation (quartz greywacke, sandstone, siltstone, and shale) occur at two miles from the traverse and outcrops of the Bitter Springs Formation (dolomite, limestone, calcilutite, and siltstone) occur about four miles from the traverse.

It has been intended to measure a sample velocity in the Bitter Springs Formation and this may not have been done. In 1961 in the Amadeus Basin 14 miles north-west of Rodinga, a velocity of 18,900 ft/s was measured in outcropping limestone beds of the Bitter Springs Formation (Moss, 1962). This velocity has been included in column 5 for comparison.

The refraction probe at Lake Keene is known to be in an area of Permian outcrop and the shallow refraction velocities measured there have been included in column 5.

The traverses at Mount Samuel, NMF 19, and Mount Beadell are known to be on areas of Cretaceous outcrop. The near-surface velocities measured on these traverses by both uphole and refraction methods have been included in Column 5 except where such near surface velocity was thought to be due to a Tertiary or weathered layer.

The velocities measured by sonic log in Hunt Yowalga No. 2 well have been tabulated in column 3. Where there is a comparison between columns 3 and 5 for the same age and type of rock, the outcrop velocity lies within the range measured in the well.

A considerable overlap exists between the velocities measured by sonic log in the rocks belonging to the different main age groups. Velocities within the Upper Proterozoic sediments are as low as 9000 ft/s and overlap most of the Permian velocity range and part of the Mesozoic Range. As might be expected this is not true to the same extent of the velocities measured by refraction and shown in column 5.

<u>Correlation of refraction velocities measured in unknown section west of Signpost</u>

The velocities measured in the five refraction probes from Mount Charles to Lake Keene are tabulated in column 7 of Table 4 alongside the age and type of rock in which it is thought they originate. The reasons for these correlations are to some extent obvious from the Table but will be discussed in greater detail below.

High velocity refractors (18,200 ft/s and greater). The known rocks in bordering areas with which velocities of 18,200 ft/s or greater may be associated are:

(a) metamorphic and igneous rocks of Archaean or Lower Proterozoic age,

(b) limestone and dolomite members of the Upper Proterozoic Bitter Springs and Boord Formations,

(c) Upper Proterozoic volcanics.

The velocity ranges overlap and no separation is possible on the basis of velocity alone.

The refractor velocity of 20,500 ft/s recorded near the surface on the Signpost traverse is correlated with undifferentiated Precambrian metamorphic rocks which outcrop within 5 miles both east and south of the traverse. The velocity is close enough to those measured at Mount Davies and Giles. A large area of granite and another area containing Proterozoic volcanics lie not far to the south-east and make other interpretations possible.

Other events that may be associated with metamorphic basement were recorded from SP 864 at NMF 19 and from SP 652 and SP 774 at Mount Beadell. Although neither velocity was measured accurately they were of the right order and the associated rocks are very deep. It is possible that these velocities originate in deeply buried rocks within the Upper Proterozoic sedimentary sequence.

It is thought that other high refractor velocities recorded are likely to have had their origin in Upper Proterozoic dolomite and limestone, in particular the 18,200 ft/s velocity at Mount Samuel, the 20,800 ft/s velocity at NMF 19 and the 19,120 to 19,750 ft/s velocity at Lake Keene. The reasons for these interpretations will be discussed below.

Intermediate velocity refractors (16,000 to 17,000 ft/s). The only refraction velocity measured in an outcropping formation, which came within the range 16,000 to 17,000 ft/s, was that measured in the Dean Quartzite, a formation near the base of the known Upper Proterozoic sedimentary section. However, velocities measured in Upper Proterozoic sediments straddled this range, viz. 14,000 ft/s at Lake Hopkins to 18,900 ft/s at Rodinga. It was thought that, with increased depths of burial and different facies, velocities intermediate, somewhat higher, and somewhat lower would be obtained.

The 16,600 to 17,000 ft/s velocity measured on all traverses from Mount Charles to Mount Beadell, because of its persistence and long period, appeared to originate in a massive refractor. On the Mount Beadell traverse the average velocity down to it had been measured as approximately 10,000 ft/s. This was thought to be about what might be expected of a mainly Permian section. It was concluded that this refraction was taking place near the top of the Upper Proterozoic section. ? Volcanics

It now seems likely that the refraction is associated with a continuation of the Hunt Oil Company reflection Horizon A (see below). This horizon was found to correspond to the top of the volcanics in Yowalga No. 2 well. The velocity of 16,600 to 17,000 ft/s seems rather low for the basalt; also the basalt layer is about one sixth of a wavelength thick and it is not known how widespread the layer is. The volcanics do not seem to have been a feature of aeromagnetic reconnaissance in the area. A large-scale angular unconformity occurs at Horizon A and it appears that the velocity of 16,600 to 17,000 ft/s must be associated with the older rocks below it.

More than a thousand feet of brick-red arkosic sandstone occurring above Horizon A has been given an Upper Proterozoic age on lithological grounds. This formation has a low velocity, comparable with the Permian section, and Horizon A is the interface at which the main increase in velocity occurs.

Two velocities within this range were measured at Lake Keene at different depths. The shallower refractor, having a velocity of 16,050 ft/s, is a highly attenuating layer. It occurs at about the depth where the aeromagnetic interpretation (Lynch, 1965) has placed an extrusive layer. It seems likely that this refraction takes place in a layer of volcanic rocks. The age of these rocks is very doubtful but they have been tentatively correlated with the Upper Proterozoic volcanics further east. The 16,350 ft/s velocity is measured at a depth greater by about a thousand feet and the refractor appears to be fairly massive. The interface might be the equivalent of Horizon A further east.

<u>Low velocity refractors (less than 12,000 ft/s)</u>. The refraction velocities measured in the unknown section west of Signpost show a gap between 16,000 and 11,600 ft/s.

The refraction velocities measured in Permian outcrops range from 8950 to 11,070 ft/s and the velocities measured by sonic log in Permian rocks in Yowalga No. 2 range from 7000 to 11,000 ft/s. The refraction velocities measured in Mesozoic outcrops range from 6000 to 9000 ft/s and the velocities measured by sonic log in Mesozoic rocks in Yowalga No. 2 range from 5000 to 10,000 ft/s. There is considerable overlap of the refraction velocity ranges.

However, it required more than velocity data alone to interpret refractors as Mesozoic or Permian.

As already mentioned, the sub-weathering velocities recorded at Mount Samuel, NMF 19, and Mount Beadell were listed in column 5 of Table 4 as Mesozoic. The next deeper events recorded in these probes had velocities from 10,000 to 11,000 ft/s and came from depths of between 500 and 1600 feet. With the additional knowledge that the Mesozoic and Permian sediments are flat-lying, and that the thickest Mesozoic section measured at any one place is the 460 feet in Browne No. 2 well, these deeper refractors were listed as Permian (see also Chapter 9).

Considerable doubt was felt about assigning an age to the rocks showing velocities of 8800 and 10,250 ft/s at a depth of 300 feet at Mount Charles. The velocities are marginal and the Mount Samuel probe shows an easterly dipping Permian refractor. These velocities were therefore listed as Mesozoic.

The velocity of 11,600 ft/s from a depth of about 3000 feet at NMF 19 could be Permian, or it could be some unknown Palaeozoic unit. However, it has been correlated with the Upper Proterozoic Sandstone encountered in Yowalga No. 2 at a depth of 1335 feet. This formation gave a sonic log velocity ranging from 9000 to 11,000 ft/s.

Correlation of reflection sections at NMF 19, Mount Beadell, and Mount Everard

It was noted in Chapter 3 that, although the Hunt Oil Company reflection Horizon A gives a strong reflection throughout most of the Yowalga survey area, there are parts of the area where the reflection almost disappears. In particular this happened at the northern end of Line 32J, which is a point of closest approach to the NMF 19 traverse.

The Horizon A reflection time at the northern ends of Hunt Oil Company Lines 12D and 12E is 0.72 second and increasing, and at the northern end of Line 32J is 0.9 second. On traverse NMF 19 the strongest reflection occurs at about 0.9 second, equivalent to a depth of about 4300 feet. There are indications of angular unconformity at this horizon. All of these factors favour the correlation of this reflection with Horizon A. The NMF 19 refraction probe indicates a 16,800-ft/s refractor at about this depth. A poor reflection occurs at about 0.62 second on the section recorded with the 7 deep hole pattern (Plate 18). This would be about the depth where the 11,600-ft/s refraction takes place and, if the correlation of this refraction in the previous chapter is correct, would represent the top of the Proterozoic section.

It is difficult to correlate the reflection section recorded on the Mount Beadell traverse with reflection sections recorded elsewhere. In the expanded-spread velocity shoot centred on SP 714 (Plate 12) reflections are seen from between 0.1 and 0.2 second all the way down the section. The strongest event occurs at about 1.3 seconds or a depth of about 6600 feet. The Mount Beadell refraction probe shows the 16,600-ft/s refractor occurring at a shallower depth of 5500 feet. It appears that this may be an area where the Horizon A reflection is relatively weak and that Horizon A should perhaps be correlated with the fair reflection at 1.15 seconds, which is at a depth of about 5500 feet. Indications are that the section above Horizon A is fairly flat in this area and the good reflection at 0.645 second would be at about the right depth to correlate with the reflection at 0.62 second at NMF 19. This reflection would then represent the top of the Proterozoic section at Mount Beadell. A comparison of the average velocities measured in the expanded-spread velocity shoot at SP 714 with the velocities measured by sonic log in Yowalga No. 2 favours the above correlations.

The correlation of the Mount Everard reflection section is again doubtful and there is no refraction work for comparison. The best guess might be that the strong event at about 0.9 second (4000 feet) would correlate with Horizon A. There is evidence of angular unconformity between this reflection and that immediately below it.

Structural indications in the Mount Samuel Gravity Low

Where the BMR seismic traverse crosses the trough associated with the Mount Samuel Gravity Low, surface structure and gravity features both deep and shallow trend south-east at about 125 to 135 degrees.

At the northern end of the trough a surface anticline occurs as a cross-structure trending north-east at about 66 degrees.

The Mount Charles traverse makes a fairly large angle with the main trend. The Mount Samuel and NMF 19 traverses make successively smaller angles. It is necessary to remember this when looking at the cross-section and Bouguer anomaly profile in Plate 4.

Although there are only a few seismic measurements of depth to metamorphic basement, these lend support to the hypothesis that the regional gravity features reflect the configuration of metamorphic basement. The measurements concerned are to the 20,500-ft/s refractor at Signpost, NMF 19, and Mount Beadell. This refractor was not recorded at Mount Charles with a shot-to-geophone distance of 63,360 feet nor at Mount Samuel with a shot-to-geophone distance of 61,200 feet, so that large depths of burial are also indicated at these locations.

The basement configuration shown in Plate 4 agrees with that interpreted from the Bouguer gravity anomaly on the assumption that the anomaly is produced solely by the contrast between low density sediments and higher density basement rocks (Lonsdale and Flavelle, 1963). The eastern flank has been made to agree with the gravity interpretation. In this interpretation a density within the basement rocks was invoked to explain the positive anomaly at Mount Charles. The interpretation of the eastern flank as a monocline is in agreement with the refraction interpretation south-west from Warburton Mission by Hunt Oil Company (1965).

It was concluded above that the 16,600 to 17,000 ft/s velocity measured on all traverses from Mount Charles to Mount Beadell originated at about reflection Horizon A. This horizon as defined by both refraction and reflection seems fairly flat and is shown in Plate 4 at a depth of about 5000 feet from Mount Samuel to beyond Mount Everard. Evidence of angular unconformity below this horizon is given by the 18,200 ft/s refractor at Mount Samuel and by the reflection sections at NMF 19 and Mount Everard.

Local gravity anomalies appear to originate at depths of a few thousand feet and must reflect density variations within the sedimentary section, probably controlled by structure. From discussions in Chapters 2 and 3 it seems likely that some negative anomalies may be associated with the incompetent core rocks of decollement or diapiric-type folds.

The velocity of 19,950 ft/s recorded in the centre of the Mount Charles traverse may be associated with a residual gravity 'low', which appears as an inflection in the gravity gradient forming the northern side of the Mount Samuel Gravity Low, at the minus 40-milligal contour. This inflection appears as though it may be a linear residual feature parallel to the axis of the Mount Samuel Gravity Low. The refractor could be the exposed core of a corresponding diapiric fold.

The 18,200 ft/s velocity recorded at Mount Samuel indicates an east dipping refractor. It could be on the north-east flank of the anticline passing beneath Browne Nos. 1 and 2 wells. The associated surface trend is mapped to within five miles south of the traverse.

An event recorded from SP 800 at NMF 19 shows an apparent velocity of 20,800 ft/s. Depth computations using assumed true velocities of both 18,200 and 20,800 ft/s put the refractor a thousand feet below the apparently massive 16,800 ft/s refractor which is correlated with Upper Proterozoic rocks. The event could be associated with a westerly dipping refractor having a true velocity of about 18,200 ft/s, similar to that recorded at Mount Samuel. The west dip would be in agreement with the mean dip shown by reflection events from about the same depth. However, the attenuating nature of the event does not agree with that at Mount Samuel. The favoured interpretation is that the event comes from a thin high velocity layer within the Upper Proterozoic sequence, probably limestone or dolomite.

The cross-structure indicated by surface geology at the northern end of the trough intersects the NMF 19 traverse. It is seen from the NMF 19 reflection section that a turn-over exists in the sedimentary section at depth and would appear to be of greater amplitude below Horizon A.

It was concluded above that the refractors having velocities from 10,000 to 11,000 ft/s at Mount Samuel, NMF 19, and Mount Beadell were of Permian age. In Chapter 9 it was seen that these refractors appeared to be thin high velocity layers near the top of the Permian section. Mostly these refractors indicate flat-lying beds several hundred feet deep. Only at Mount Samuel are there indications of appreciable dip and possible thickening of the Mesozoic section at the eastern end of the traverse.

Structural indications at Lake Keene

In Plate 2 the Lake Keene seismic traverse is seen to be in the centre of a large gravity 'low' - Feature No. 1, the Herbert Gravity Sub-Depression. In Plate 24, reflections occurring down to the bottom of the section might indicate undistorted sedimentary layers down to about 50,000 feet. As pointed out in Chapter 9 the strongest reflection has a centre time of 4.2 seconds, equivalent to a depth of 38,000 feet. The assumed average velocity within the overlying sediments of approximately 19,000 ft/s gives also a slight west dip of 2 degrees. This velocity may be somewhat high and a lower velocity would give a correspondingly smaller depth and greater dip. In Plate 4 the metamorphic basement has been joined to the strong event at 38,000 feet. There is very little justification for this procedure but the depth is probably of the right order and a basement configuration is produced which is in qualitative agreement with the regional gravity profile.

In Plate 3 the Lake Keene traverse is seen to be approximately in line with the crest of an anticline where it starts plunging to the east. The structure interpreted from aeromagnetic measurements is associated with a relatively shallow extrusive layer (Lynch, 1965), which has been correlated above the 16,050-ft/s refractor.

Refracted arrivals with a high velocity of 19,120 to 19,750 ft/s define a refractor dipping east from a minimum depth of 3500 feet. Shot-point intercepts indicate deepening of the refractor to the west also. The shallower 16,350-ft/s refractor, which has been tentatively correlated with the 16,600 to 17,000-ft/s refractor further east, shows a small amount of turn-over.

The reflection section in Plate 24 shows a flat basement at 38,000 feet (?) dipping gently to the west. There is an indication in this section of steeper east dip at shallower depth.

The overall picture is consistent with decollement or diapiric-type folding. The 19,120 to 19,750-ft/s refractor could be a massive Proterozoic limestone or dolomite in the core of the fold.

## 11. CONCLUSIONS

The following conclusions are drawn with regard to the efficacy of the seismic method in the area of the BMR seismic traverse:

1. The reflection method can give usable results on areas of Cretaceous outcrop, provided sufficiently large numbers of geophones and shot-holes are used in two-dimensional arrays.

General comparison with more recent surveys has shown that efforts of the same order using the 'Thumper' and 'Vibroseis' surface input methods give comparable results. These later surveys have also shown the possibility of obtaining improved results with a C.D.P. technique.

2. The refraction method can be used to follow two principal refractors having velocities between 10,000 and 11,000 ft/s and between 16,300 and 17,000 ft/s.

Deeper and higher velocity refractors may be followed in parts of the area. In particular an apparently massive refractor having a velocity of 19,320 to 19,750 ft/s has been followed on the Lake Keene traverse and a refractor having a velocity of about 20,500 ft/s has been recorded in the Mount Samuel Gravity Low.

3. It may be possible to map deep sedimentary structure and basement configuration with a simple and rapid reflection technique using large offsets, as at Lake Keene.

The main conclusions drawn with regard to the geological objective of the survey are set out below. They are also summarised in diagramatic form in Plate 4.

of the Permian section. The results of the sonic log in Yowalga No. 2 well support this assumption. The base of the Permian section is undefined although the boundary indicated in Plate 4 is a possibility.

7. Nothing has been found to show that the Mesozoic section is anything other than a thin veneer of flat-lying rocks as expected from surface geology. A possible slight thickening of the sequence occurs under Mount Samuel if the interpretation of the Mount Samuel refraction probe is correct. This thickening would coincide with a surface syncline mapped by photogeology.

8. Anticlinal folds, below the unconformity within the Upper Proterozoic, possibly occur at Mount Charles, between NMF 19 and Mount Samuel, and at Lake Keene.

These folds cannot be postulated on seismic evidence. A tenuous justification is found only in the combination of geology, gravity, aeromagnetic, and seismic results.

9. The cross-structure indicated by photogeology at the north-western end of the Mount Samuel Gravity Low occurs at depth.

In the event that the above conclusions are correct and unless the possibility of Upper Proterozoic oil is allowed, it would appear that the finding of significant amounts of accumulated hydrocarbons in the vicinity of the BMR traverse is unlikely. It is of interest to note that hydrocarbons were found in the evaporite sequences at the base of both Browne No. 1 and Browne No. 2 wells (Jackson, 1966b).

It must be remembered that some of the above conclusions are highly speculative and, in particular, those concerning the nature and age of the upper part of the section at Lake Keene. It is recommended that a stratigraphic hole be drilled on the anticlinal structure at Lake Keene.

1. A thick sedimentary section exists along the whole length of the BMR seismic traverse, the maximum thickness measured being a possible 38,000 feet at Lake Keene.

2. The traverse appears to cross two major troughs, which correspond to the Mount Samuel Gravity Low and the Herbert Gravity Sub-Depression. Rough indications were obtained that regional gravity features bear a direct relation to metamorphic basement configuration.

The amount of seismic evidence obtained showing the depth to metamorphic basement is small. As already pointed out, the 20,500 ft/s refractor could lie within the sedimentary section. The depth to metamorphic basement in the Mount Samuel Gravity Low could be greater and more nearly equal to that in the Herbert Gravity Sub-Depression. The aeromagnetic work in the Mount Samuel Gravity Low, which indicates a depth to magnetic basement similar to that shown in Plate 4, was sparse.

3. The greater part of the sedimentary section is of Upper Proterozoic age.

As a result of the BMR survey, it was thought that the 16,300 to 17,000-ft/s refractor would be about the top of the Proterozoic section but that the unknown section at shallower depth might be explained by the Lower Palaeozoic to Upper Proterozoic sandstone mapped by Wells (1963) at the Iragana Inlier.

4. A major angular unconformity exists within one or two thousand feet of the top of the Upper Proterozoic sequence. Sediments below this unconformity have been subjected to folding, which was probably due to salt movement and which was parallel to the edge of the basin in the Mount Samuel Gravity Low.

This conclusion was drawn from the results of the Yowalga seismic survey combined with gravity, surface geology, and the results of the Browne and Yowalga wells. There were indications in the results of the BMR seismic survey and this model allowed the possible explanation of various scattered results.

5. The two or three thousand feet of section above the angular unconformity and below the base of the Permian is probably Lower Palaeozoic or Upper Proterozoic sandstone. It appears to be relatively flat-lying although the folding movement appears to have continued to some extent after erosion took place.

6. The Permian sequence may be up to 2000 feet thick. It is mainly flat-lying.

In interpreting the results of the BMR seismic survey it had been assumed that the 10,000 to 11,000-ft/s refractor lay near the top

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# APPENDIX A

## STAFF AND EQUIPMENT

### Staff

| | 1961 | 1962 |
|---|---|---|
| Party leader | S.J. Watson | A. Turpie |
| Geophysicists | K.F. Fowler | K. F. Fowler |
| | A. Turpie (from 4/10) | G. Bow |
| | | M. Curtin (to 22/10) |
| Surveyors from Dept of the Interior | M. Francki | T. Howard |
| | R. Leetham | R. Leetham |
| Clerk | E.J. Quinn | R. Short |
| Observer | G.L. Abbs | J.K. Grace |
| Shooter | R.J.E. Cherry | C. Wood |
| Toolpusher | J.G. Halls | J.G. Halls |
| Drillers | J. Chandler | J. Chandler |
| | R.O. Larter | K. Suehle |
| | J. Keunen | J. Keunen |
| | A. Zoska | L. Watts |
| Mechanic | I.D. Pirie | E. MacIntosh |
| Field-hands | 11 | 13 |

(2 cooks, 1 mechanic, 1 tanker driver, 3 recorder crew, 1 shooter's offsider, 1 stores driver and miscellaneous, and 2 surveyors assistants; plus 2 drill assistants in 1962 only).

### Equipment

| | | |
|---|---|---|
| Seismic amplifiers | : | Texas Instruments 7000B |
| Seismic oscillograph | : | Electro-Tech ET66 |
| Magnetic recorder | : | Electro-Tech DS7/700 |
| Geophones | : | 612 T.I.C. and Electro-Tech, 20 c/s in groups of 6<br>100 T.I.C., 6 c/s (1961)<br>100 EVS 8B 4.5 c/s in groups of 4 (1962) |
| Transceivers (Communications and time-breaks) | : | 3 Traeger 59 M10<br>3 Traeger TM 2 (1962 only) |
| Blasters | : | 1 Electro Tech, BC-2-5<br>1 S.I.E., SCD 2000A<br>1 T.I.C |
| Drills | : | 1 Mayhew 1000 (from 2/10/62)<br>1 Failing 750<br>2 Carey |

Note: Whereas communications had been almost non-existent in 1961 using the Traeger 59 M10 on 2140 Kc/s, communications were excellent in 1962 using the TM 2 on 6815 Kc/s.

Vehicles

| | | |
|---|---|---|
| Land Rovers L.W.B. | : | 2 Geophone Trucks<br>2 Surveyors |
| Land Rover Station Wagon | : | 1 General Purpose (1962 only) |
| International<br>4 x 4, 1 ton, AA120 | : | 1 Party Leader's Ute.<br>1 Recording Truck |
| Bedford Truck<br>4 x 4, 3 ton | : | 3 Tankers, 700 gallon<br>1 Tanker, 1000 gallon<br>1 Shooting Truck<br>1 Workshop Truck<br>1 Stores Truck<br>2 Carey Drills<br>1 Failing Drill |
| International R190<br>4 x 4 (from 20/10/62) | : | 1 Mayhew Drill |
| Chamberlain Tractor | : | 1 |
| 4 Wheel Trailers, 4 ton | : | 2 Tray Body<br>1 Kitchen<br>1 Magazine |
| 4 Wheel Trailer, 30 cwt. | : | 1 Workshop Spares |
| Office Caravan | : | 1 |

## APPENDIX B

## TABLE OF OPERATIONS

1961

| | | |
|---|---|---|
| Sedimentary Basin | : | Officer |
| Area | : | Mount Davies to Mount Beadell |
| Camp sites | : | 1. Giles 9th to 22nd September<br>2. Signpost 23rd September to 23rd October |
| Shooting commenced | : | 6th September |
| Shooting ceased | : | 18th October |
| Miles surveyed | : | 13¼ |
| Topographic survey control | : | MSL Port Augusta |
| Total footage drilled | : | 5463 |
| Explosives used | : | 3016 lb Geophex |
| No. of detonators used | : | 206 |
| Datum levels for corrections (feet above sea level) | : | Mount Davies 2000<br>Giles 1900<br>Rawlinson 1800<br>Lake Hopkins 1600<br>Lake Christopher 1300<br>Signpost 1600<br>Mount Charles 1500<br>Mount Samuel 1450<br>NMF 19 1400<br>Mount Beadell 1450<br>Iragana Turn-off 1650 |
| Source of reflection velocity distribution | : | Velocity shoot at Mount Beadell (1962) |
| Method used in refraction computation | : | Vale and Smith (1961) |
| Method used in weathering computation | : | Vale (1960), reciprocal time method |

### Reflection Shooting Data

| | | |
|---|---|---|
| Shot-point intervals | : | 1320 ft |
| Geophone groups | : | 6 x 20-c/s geophones in line at 22-ft intervals |
| Geophone group interval | : | 110 ft |
| Number of holes shot | : | 21 |
| Miles traversed | : | 6⅓ miles |
| Usual recording filters | : | K18 K75 |
| Usual playback filters | : | K30 K57 |
| Common charge sizes | : | 5 to 10 lb |
| Common shooting depth | : | 50 to 100 ft |

### Refraction Shooting Data

| | | |
|---|---|---|
| Geophone groups | : | 2 x 6-c/s geophones in parallel |
| Geophone group interval | : | 220 ft |
| Number of holes shot | : | 49 |
| Usual recording filter | : | KO K57 |
| Number of refraction traverses | : | 11 |

| | | |
|---|---|---|
| Charge sizes | : | 10 to 200 lb |
| Miles traversed | : | $12\frac{1}{4}$ |
| Maximum shot-to-geophone distance | : | $2\frac{3}{4}$ miles |

1962

| | | |
|---|---|---|
| Sedimentary basin | : | Officer |
| Area | : | Mount Charles to Lake Keene |
| Camp sites | : | Halfway between NMF 19 and Mount Beadell |
| Shooting commenced | : | 18th September |
| Shooting completed | : | 4th December |
| Miles surveyed | : | 138 |
| Topographic survey control | : | Queensland State Datum |
| Total footage drilled | : | 44,688 ft |
| Explosives used | : | 11,267 lb Geophex<br>3,200 lb Nitrolite |

| Traverse | Datum (ft A.S.L.) | $V_o$ (ft/s) | $V_e$ (ft/s) |
|---|---|---|---|
| Signpost | 1600 | 1000 | 6000 |
| Mount Charles | 1450 | 4000 | 8800<br>10,250 |
| Mount Samuel | 1450 | 3000 | 7600 |
| NMF 19 | 1400 Refln.<br>1450 Refrn. | 3200 | 7000 |
| Mount Beadell | 1450 | 3000 | 10,000 |
| Mount Everard | 1450 | 1000 | 7000 |
| Lake Keene | 1300 | 5000 | 9000 |

Source of velocity distribution : Extended-spread velocity shoot at Mount Beadell

Reflection Shooting Data

| | | |
|---|---|---|
| Shot-point interval | : | (a) 1320 ft (b) 1800 ft |
| Geophone group | : | See reflection sections |
| Geophone group interval | : | (a) 110 ft (b) 150 ft |
| Holes shot: | | |

| Description | Depth | Number shot | Purpose |
|---|---|---|---|
| Single shallow | 3 ft | 27 | Weathering |
| Single shallow | 8 ft | 7 | Noise test |
| Single deep | 85 ft | 7 | Noise test |
| Single deep | 120 ft | 31 | Weathering |
| Single deep | 150 ft | 4 holes 76 shots | Uphole shoot |
| 3 deep-Shot-hole pattern C | 85 ft | 2 | Comparison |
| 7 deep-Shot-hole pattern B | 85 ft | 9 | Reflection traverse |
| 36 shallow-Shot-hole pattern A | 15 ft | 33 | Reflection traverse |

| | |
|---|---|
| Miles traversed | : $6\frac{1}{2}$ miles + extended-spread velocity |
| Usual recording filter | : 18K to 66K |
| Usual playback filter | : 24K to 57K |
| Common charge sizes | : (a) 36 x 2/3 lb<br>(b) 36 x $2\frac{1}{2}$ lb |
| Weathering corrections | : Vale (1960) |
| Grading system | : Gaby (1947) |

Refraction Shooting Data

| | |
|---|---|
| Geophone group | : Four EVS 8 4.5 c/s at 22-ft intervals in a line at right angles to the traverse |
| Geophone group interval | : (c) 220 ft (d) 300 ft |
| Holes shot | : 80 |
| Usual recording filter | : 0, 57K |
| Number of refraction traverses | : 5 |
| Charge sizes | : 10 to 1600 lb |
| Maximum shot-to-geophone distance | : $17\frac{1}{4}$ miles |
| Weathering control | : Reflection spreads short refraction and uphole shoots |
| Weathering and elevation corrections | : Vale (1960), reciprocal time method |

Notes

(a) Mount Beadell, NMF 19
(b) Mount Everard
(c) Mount Charles, NMF 19, Mount Beadell
(d) Mount Samuel, Mount Everard, Lake Keene

# APPENDIX C

## SHOT-HOLE DRILLING STATISTICS

### 1961

#### Seismic shot-point drilling

| | | |
|---|---|---|
| Drilling rigs | : | 2 Careys |
| Total footage drilled | : | 5739 |
| No. of holes drilled | : | 156 |
| Average depth of hole | : | 37 ft |
| Deepest hole drilled | : | 150 ft |
| Drilling time | : | 169½ hr |
| Travelling and rigging-up time | : | 143½ hr |
| Time lost standing by recorder | : | 26 |
| Time lost waiting for water | : | 6½ hr |
| Time lost because of stuck pipe | : | 2 hr |
| No. of shifts worked | : | 53 |
| Maintenance to drills | : | 81 hr |
| Bentonite used | : | 6½ bags |
| Drilling rate | : | 33.8 ft/hr |

#### Water-bore drilling

| | | |
|---|---|---|
| Total footage drilled | : | 665 |
| No. of holes drilled | : | 7 |
| Drilling time | : | 20½ hr |
| Travelling time | : | 16½ hr |
| Time taken bailing and casing the holes and setting-up the pump head | : | 41½ hr |
| No. of shifts worked | : | 9 |

### 1962

(including water bore and core holes)

| | | |
|---|---|---|
| Total footage drilled | : | 44,688 |
| Total No. of holes drilled | : | 1,758 |
| Average depth of holes | : | 254 ft |
| Deepest hole drilled | : | 431 ft |
| Travelling time and rigging up | : | 362½ |
| Time lost waiting on water | : | 47¾ |
| Time lost repairs to drill | : | 70½ |
| Time lost because of rain | : | 1¾ |
| Time lost repairs to engine rig | : | 40½ |
| Time waiting on surveyors | : | 4¾ |
| Time lost stand by recorder | : | 14¼ |
| Drilling time | : | 710 hr |
| No. of shifts worked | : | 138 |
| Maintenance to drill | : | 148½ |
| Bentonite used | : | 5 bags |
| Fishing job | : | 24¼ |

| | | |
|---|---|---|
| Drilling rate | : | 62.9 ft/hr |
| Running casing and baling | : | 14 hr |
| Freeing bogged vehicle | : | 1 hr |
| Working on water bore | : | 92 hr |

<u>Note</u>:

The time lost waiting for water was mainly due to the breakdown of water tankers.

## APPENDIX D

### WATER SUPPLIES

During the early part of the survey water was obtained from established bores at Mount Davies, Giles Meteorological Station, and Warburton Mission. Later in 1961 and during the whole of the 1962 survey water was obtained for both drilling and camp supply from three shallow bores drilled in the survey area. Details of these bores have been given by Wells (1963) and their locations are shown in Plate 1. Water from the bore 11 miles south of Signpost was brackish and could be used for drilling only. For most of the 1962 survey water was obtained from the bore on the western edge of the sand dunes near Lake Breaden. This bore was sited in a clump of gum trees beside the road and it gave a continuous 80 gallons per hour of excellent drinking water. A bore 7 miles east of NMF 23 gave a continuous 240 gallons per hour of good drinking water. This bore was sited near limestone outcrops and amongst scattered gum trees. It was not realised until after the bore was drilled that it must be near a water soak used by David Carnegie in 1894.

Water was found at 15 feet in shot-holes at Mount Samuel.

PLATE I


MAP OF THE GIBSON DESERT AREA SHOWING SURFACE GEOLOGY AND SEISMIC TRAVERSES

G51/B3-8

GILES-CARNEGIE 1961-62


SOURCE OF GRAVITY DATA

B.M.R. (Lonsdale and Flavelle, 1963)

HUNT OIL CO. (Bazhaw and Jackson, 1965)

For sources of Geology see plate G51/B3-8

SEISMIC CORE HOLE

SEISMIC WATER BORE

SEISMIC TRAVERSE (BMR)

SEISMIC TRAVERSE (COMPANY)

PROPOSED TRAVERSE (not shot)

WELL

GEOLOGICAL BOUNDARY (approximate)

ROADS

RIVER OR STREAM

BOUGUER ANOMALY CONTOURS (5 milligal interval)

GRAVITY 'HIGH'

GRAVITY 'LOW'

LAKE

| | | |
|---|---|---|
| CAINOZOIC | Quaternary | Q |
| | Undifferentiated | Cz |
| MESOZOIC | | M |
| PALAEOZOIC | Permian | P |
| | Older Palaeozoic | Pz |
| PRECAMBRIAN | Sediments | P̱ |
| | Metamorphic and Igneous | pЄ |

SYNCLINAL AXIS

ANTICLINAL AXIS

SCALE

10 0 10 20 30 40 MILES

## MAP OF THE GIBSON DESERT AREA SHOWING SURFACE GEOLOGY, SEISMIC TRAVERSES AND BOUGUER ANOMALY CONTOURS

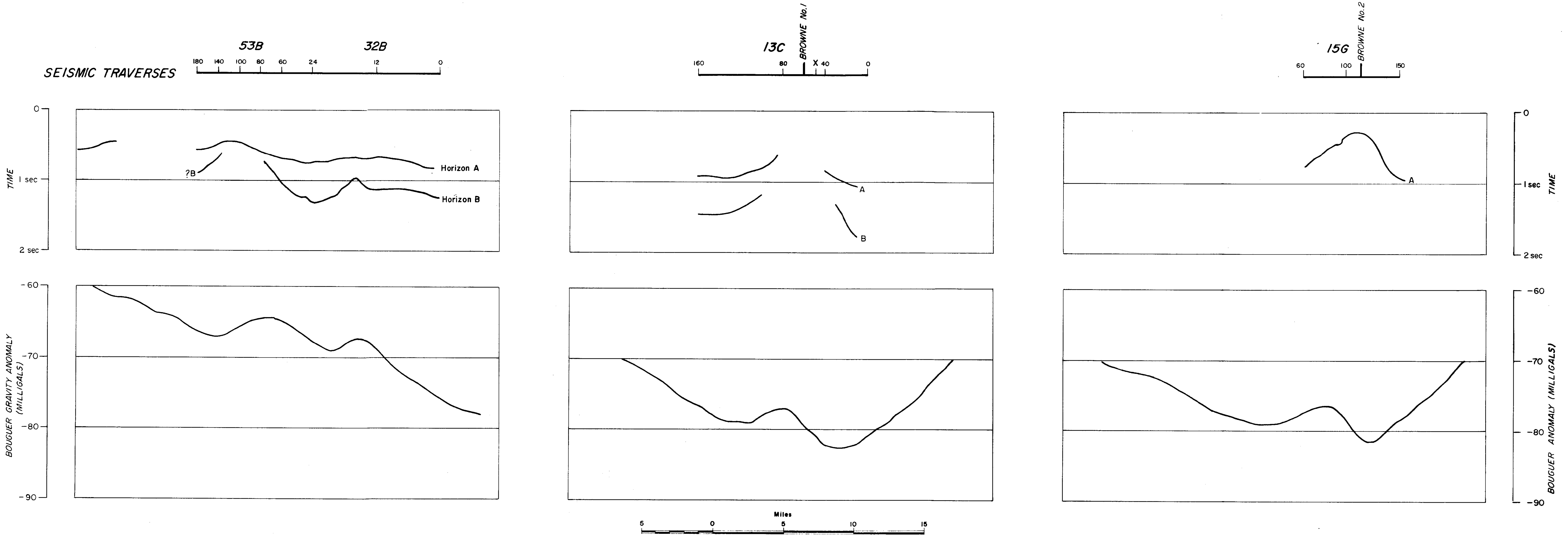
G51/B3-23


**MAP OF THE GIBSON DESERT AREA SHOWING SURFACE GEOLOGY, SEISMIC TRAVERSES AND CONTOURS OF DEPTH TO MAGNETIC BASEMENT**

G51/B3-24


PLATE 4
SEISMIC TRAVERSES
LAKE KEENE TRAVERSE
MOUNT EVERARD TRAVERSE
N.M.F. 19 TRAVERSE
MOUNT BEADELL TRAVERSE
MOUNT SAMUEL TRAVERSE
MOUNT CHARLES TRAVERSE
SIGNPOST TRAVERSE
DIRECTION OF CROSS-SECTION
DATUM 1600 ft A.M.S.L.
DEPTH BELOW DATUM (FEET)
BOUGUER GRAVITY ANOMALY (MILLIGALS)
Possible décollement type fold
Axial direction 90°
Possible diapiric fold
Axial direction 123°
B.M.R. GRAVITY SURVEY
(Lonsdale and Flavelle, 1963)
LENNIS-BREADEN GRAVITY SURVEY
(Bazhow and Jackson, 1965)
LENNIS-BREADEN B.M.R.
MT CHARLES GRAVITY HIGH
WARRI GRAVITY RIDGE
HERBERT GRAVITY SUB-DEPRESSION
MADLEY GRAVITY SWELL
MT SAMUEL GRAVITY LOW
GIBSON GRAVITY DEPRESSION
LEGEND
REFLECTION HORIZON
REFRACTION HORIZON WITH ASSOCIATED VELOCITY
M MESOZOIC
P PERMIAN
Pzl LOWER PALAEOZOIC
PROTEROZOIC SEDIMENTS
p€ PRECAMBRIAN METAMORPHIC OR IGNEOUS
HORIZONTAL SCALE
MILES
INTERPRETATIVE CROSS-SECTION ALONG THE SEISMIC TRAVERSES
TO ACCOMPANY RECORD No. 1967/123
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics
G51/B3-25

PLATE 5




X = Axis of surface anticline

Seismic results after Yowalga seismic survey ( Mickleberry, 1964)

Gravity results after Lennis-Breaden gravity surveys ( Bazhaw and Jackson, 1965)

COMPARISON OF SEISMIC AND GRAVITY PROFILES
IN THE MOUNT SAMUEL GRAVITY LOW

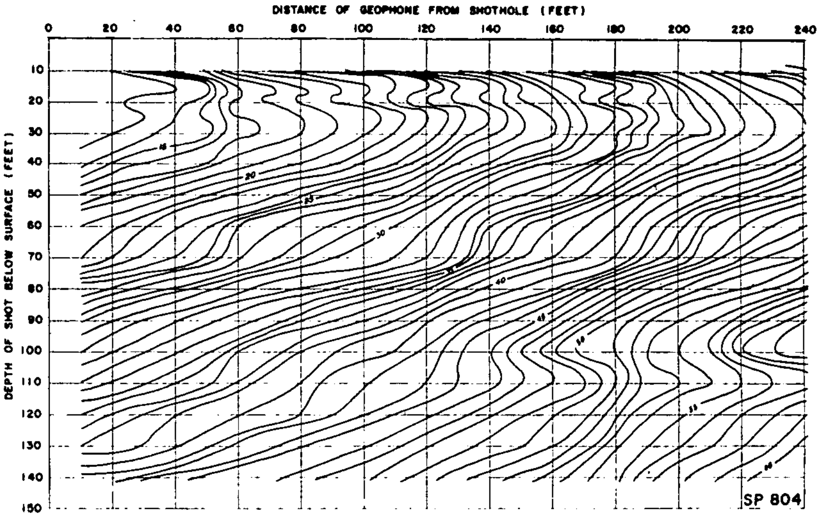
GILES - CARNEGIE SEISMIC SURVEY

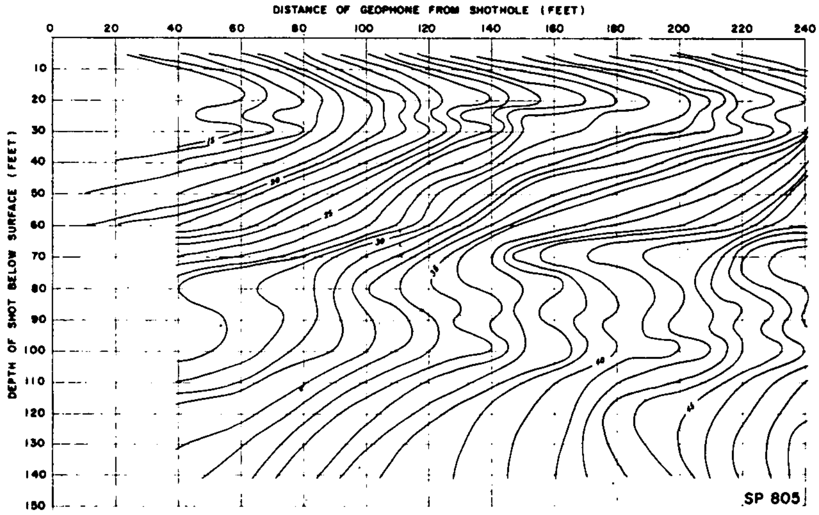
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

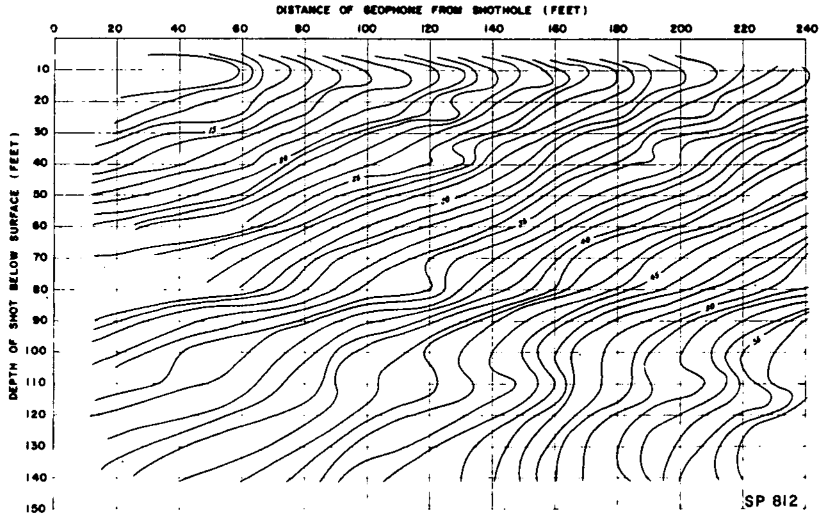
G51 / B3 - 26

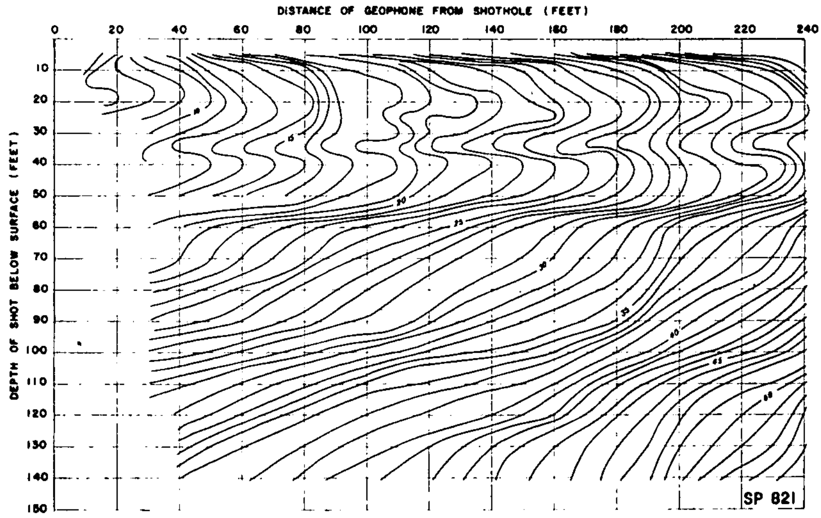
TO ACCOMPANY RECORD No. 1967/123

# PLATE 6



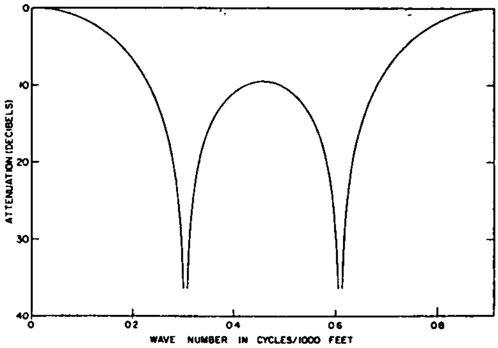

GILES - CARNEGIE SEISMIC SURVEY 1962

TRAVERSE NMF 19

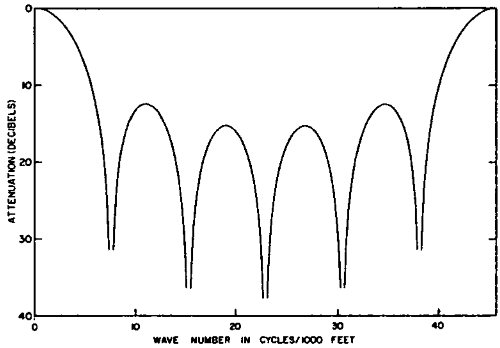
ISOCHRONS FROM UPHOLE SHOOTS

TO ACCOMPANY RECORD No. 1967/123

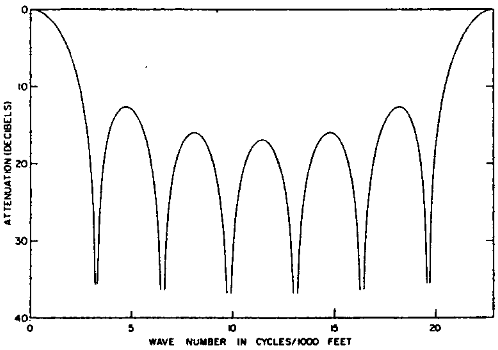
G52/B3-51



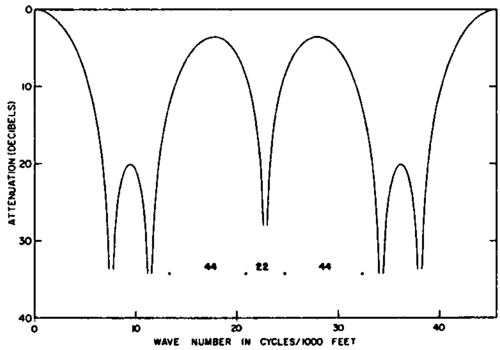

*3 HOLES IN LINE AT 110 FOOT INTERVALS*



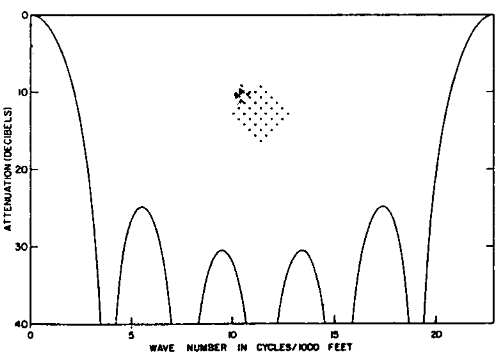

*6 GEOPHONES IN LINE AT 22 FOOT INTERVALS*




*7 HOLES IN LINE AT 44 FOOT INTERVALS*




*4 GEOPHONES IN LINE AT 44, 22, AND 44 FOOT INTERVALS*




*36 HOLES IN A DIAMOND PATTERN*

GILES - CARNEGIE SEISMIC SURVEY

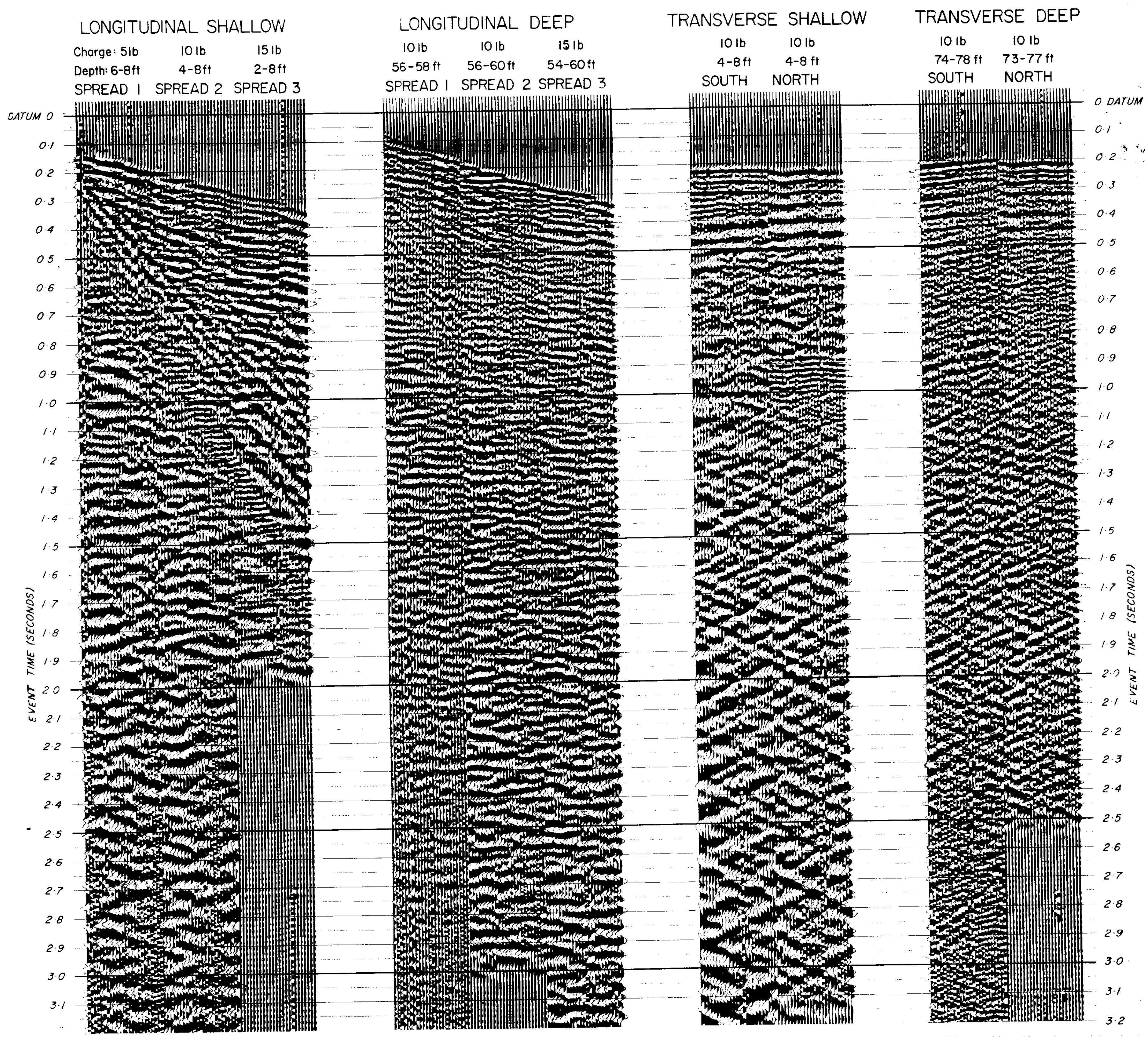
WA, 1961/2

# RESPONSE CURVES FOR HOLE AND GEOPHONE PATTERNS

*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics* G51/B3-29

TO ACCOMPANY RECORD No. 1967/123

**PLATE 8**




## RECORD SECTION

RECORDING INFORMATION

*Magnetic Recorder*: ETL DS7/700

*Amplifiers*: 7000B

*Filters*: 0-66K

*A.G.C.*: W.B.

*Gain Initial*: -50 to 55

*Final*: -20

*Geophones*: E.T.L. EVS 2B 20 c/s

*Geophone pattern*: See diagram

*Shot-hole pattern*: See diagram

PLAYBACK INFORMATION

*Filters*: 1/25-1/60

*A.G.C.*: S.S.

*Gain Initial*: -10

*Final*: -10

*Trip delay*: Nil

*Compositing*: Nil

HORIZONTAL SCALE

Trace interval — longitudinal 30'
— transverse 5'

GILES-CARNEGIE SEISMIC SURVEY, 1962

## NOISE TESTS

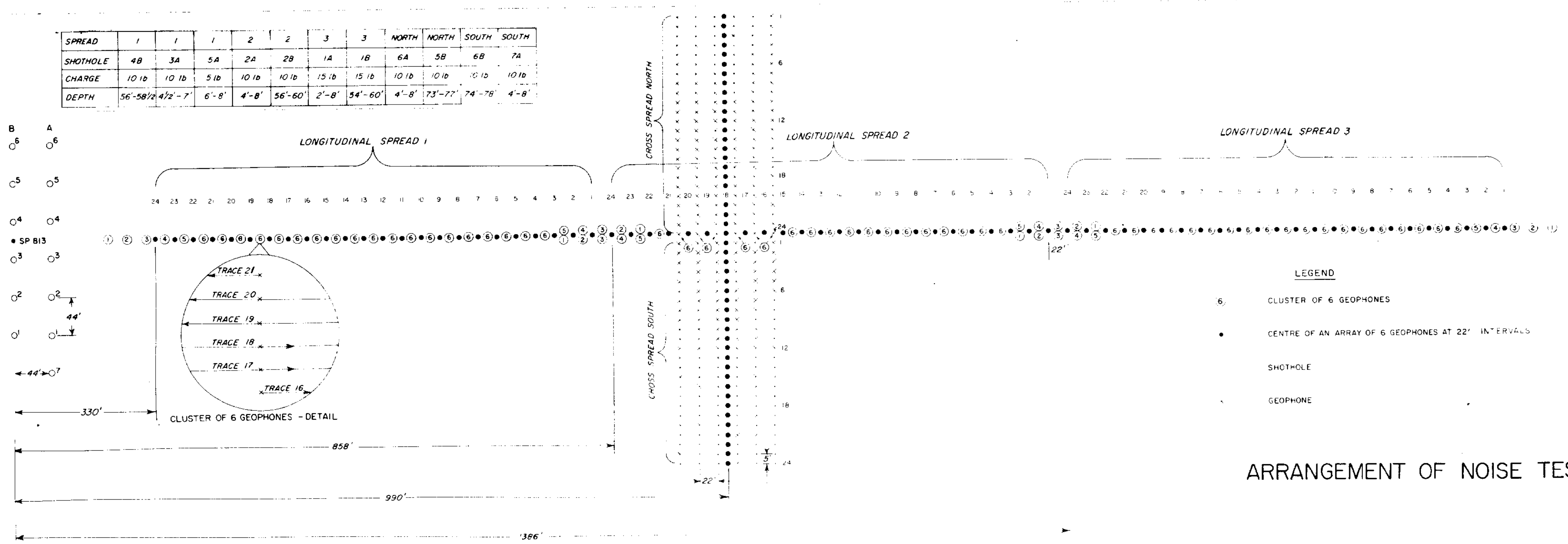
NMF 19 TRAVERSE/SHOT-POINT 813

RECORDED BY: *Seismic Party No. 2*

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

G51/B3-10

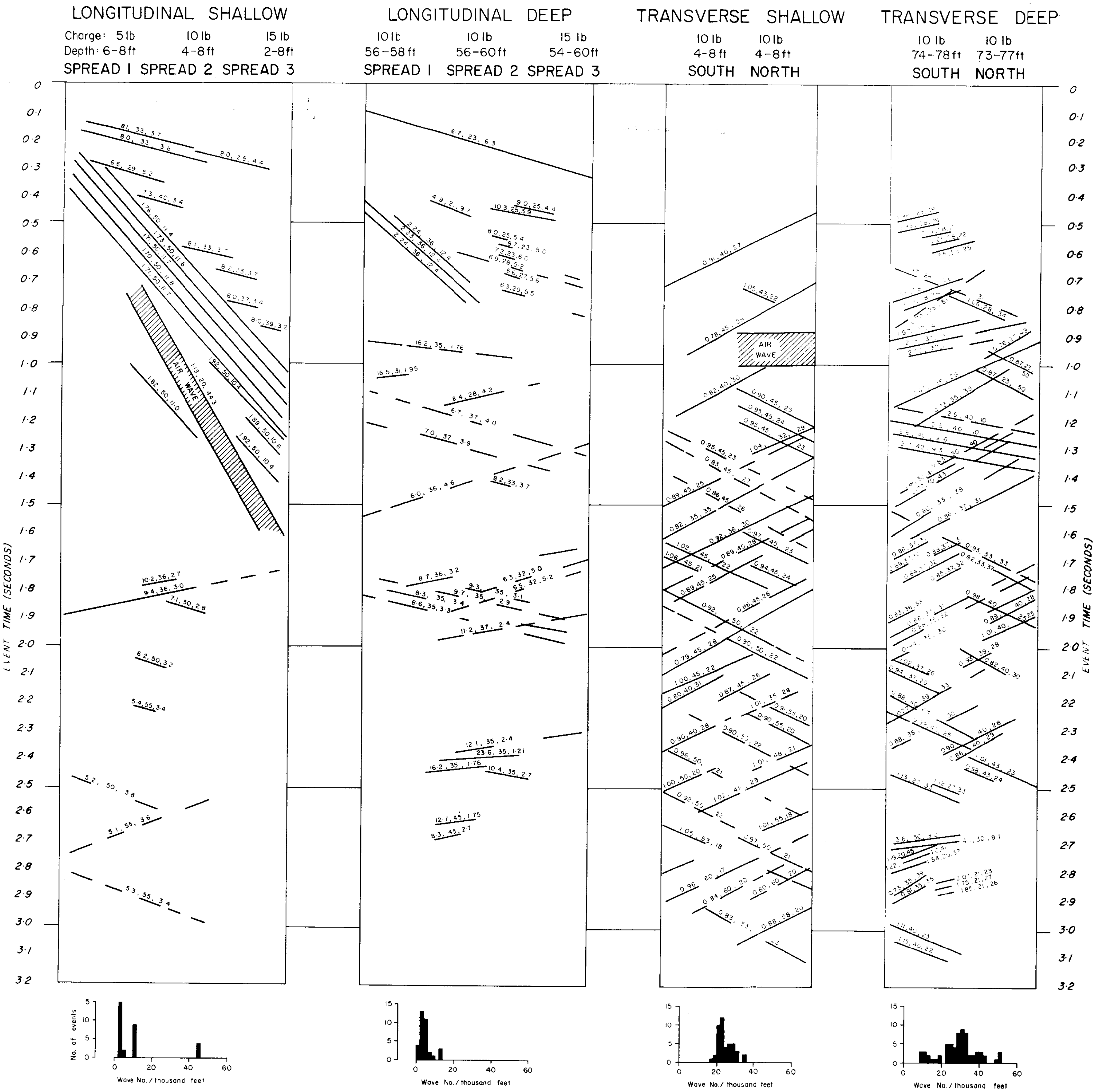
| SPREAD | 1 | 1 | 1 | 2 | 2 | 3 | 3 | NORTH | NORTH | SOUTH | SOUTH |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SHOTHOLE | 4B | 3A | 5A | 2A | 2B | 1A | 1B | 6A | 5B | 6B | 7A |
| CHARGE | 10 lb | 10 lb | 5 lb | 10 lb | 10 lb | 15 lb | 15 lb | 10 lb | 10 lb | 10 lb | 10 lb |
| DEPTH | 56'-58½' | 4½'-7' | 6'-8' | 4'-8' | 56'-60' | 2'-8' | 54'-60' | 4'-8' | 73'-77' | 74'-78' | 4'-8' |




ARRANGEMENT OF NOISE TEST

TO ACCOMPANY RECORD No 1967/123

**PLATE 9**




## RECORDING INFORMATION

*Magnetic Recorder*: ETL DS7/700

*Amplifiers*: 7000 B

*Filters*: 0-66K

*A.G.C.*: W.B.

*Gain Initial*: -50 to 55

*Final*: -20

*Geophones*: E.T.L. EVS 2B 20 c/s

*Geophone pattern*:

6 geophones in line at 22' intervals

*Shot-hole pattern*:

Single holes, depth and charge as above

## PLAYBACK INFORMATION

| | |
|---|---|
| *Filters*: | 1/25-1/60 |
| *A.G.C.*: | S.S. |
| *Gain Initial*: | -10 |
| *Final*: | -10 |
| *Trip delay*: | Nil |
| *Compositing*: | Nil |

## VELOCITY INFORMATION

HORIZONTAL SCALE

Longitudinal — 360'/inch

Transverse — 60'/inch

LEGEND

a,b,c
a Apparent velocity in thousands of feet/second
b Period in milliseconds
c Wave number in cycles per thousand feet

# GILES-CARNEGIE SEISMIC SURVEY, 1962
# INTERPRETATION OF NOISE TESTS
## NMF 19 TRAVERSE/SHOT-POINT 813

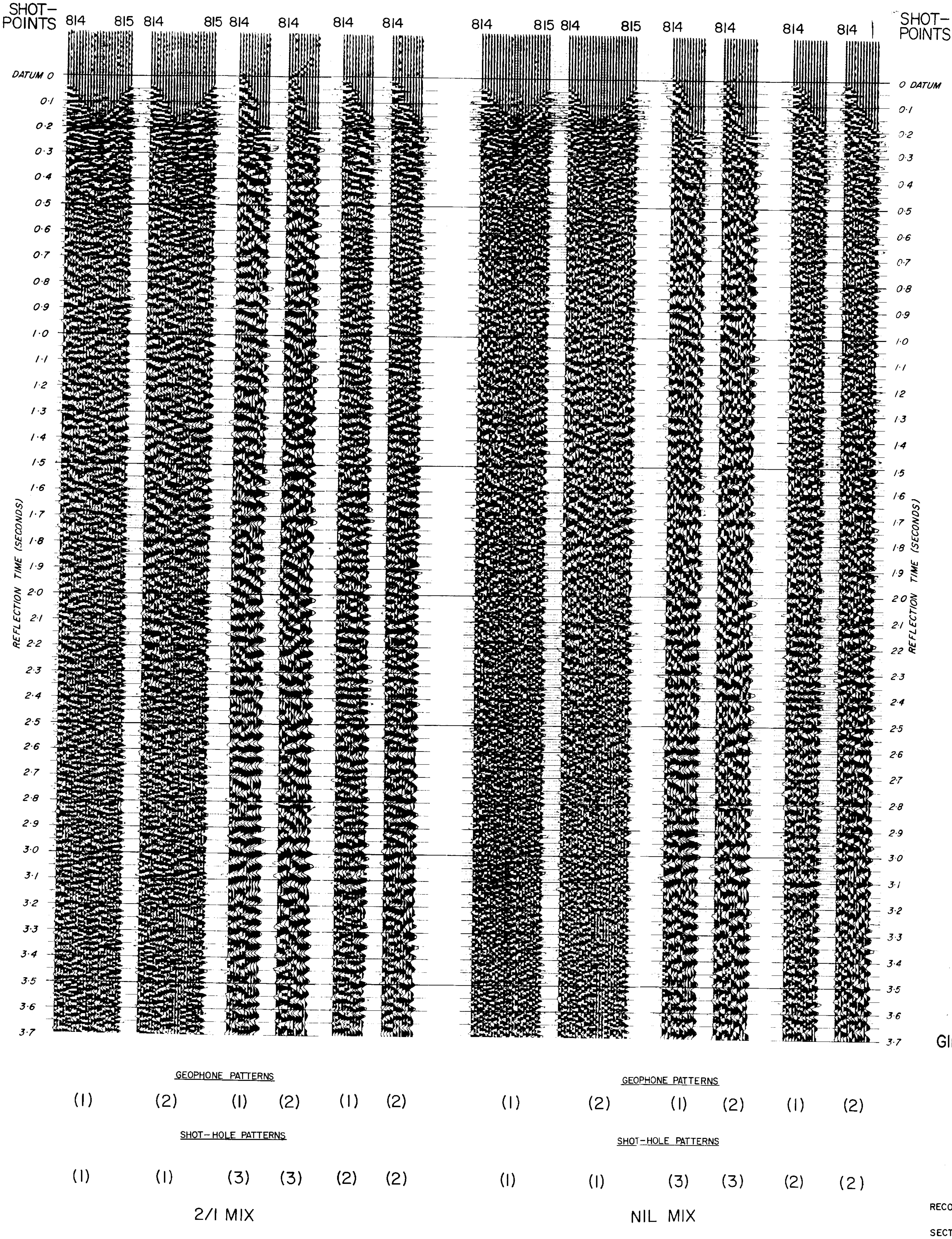
RECORDED BY: *Seismic Party No. 2*

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

G51/B3-22

TO ACCOMPANY RECORD No 1967/123

**PLATE 10**




# CORRECTED RECORD SECTION

RECORDING INFORMATION

*Magnetic Recorder :* DS7-700

*Amplifiers :* 7000 B

*Filters :* K18 - K66

*A.G.C. :* W.B.

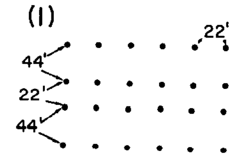
*Gain Initial :* -50

*Final :* Max.

*Geophones :* EVS 2B - 20 c/s

*Geophone pattern :* Station interval 110'

(1)



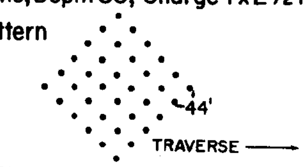

(2) 6 / Trace, 22' apart in line

*Shot-hole pattern :*

(1) 3 holes, 110' apart in line, Depth 80', Charge 3 x 5 lbs

(2) 7 holes 44' apart in line, Depth 80', Charge 7 x 2½ lbs

(3) 36 hole diamond pattern
Depth 13'
Charge 36 x ⅔ lb




PLAYBACK INFORMATION

*Filters :* 1/25 - 1/60

*A.G.C. :* S.S.

*Gain Initial :* -50

*Final :* -30

*Trip delay :* 0

*Compositing :*
as indicated

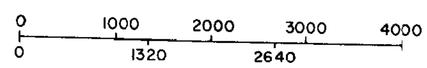
VELOCITY INFORMATION

$t^2 : x^2$

at SP714 Mount Beadell traverse

HORIZONTAL SCALE

FEET




## GILES - CARNEGIE SEISMIC SURVEY, 1962

## NMF 19 TRAVERSE

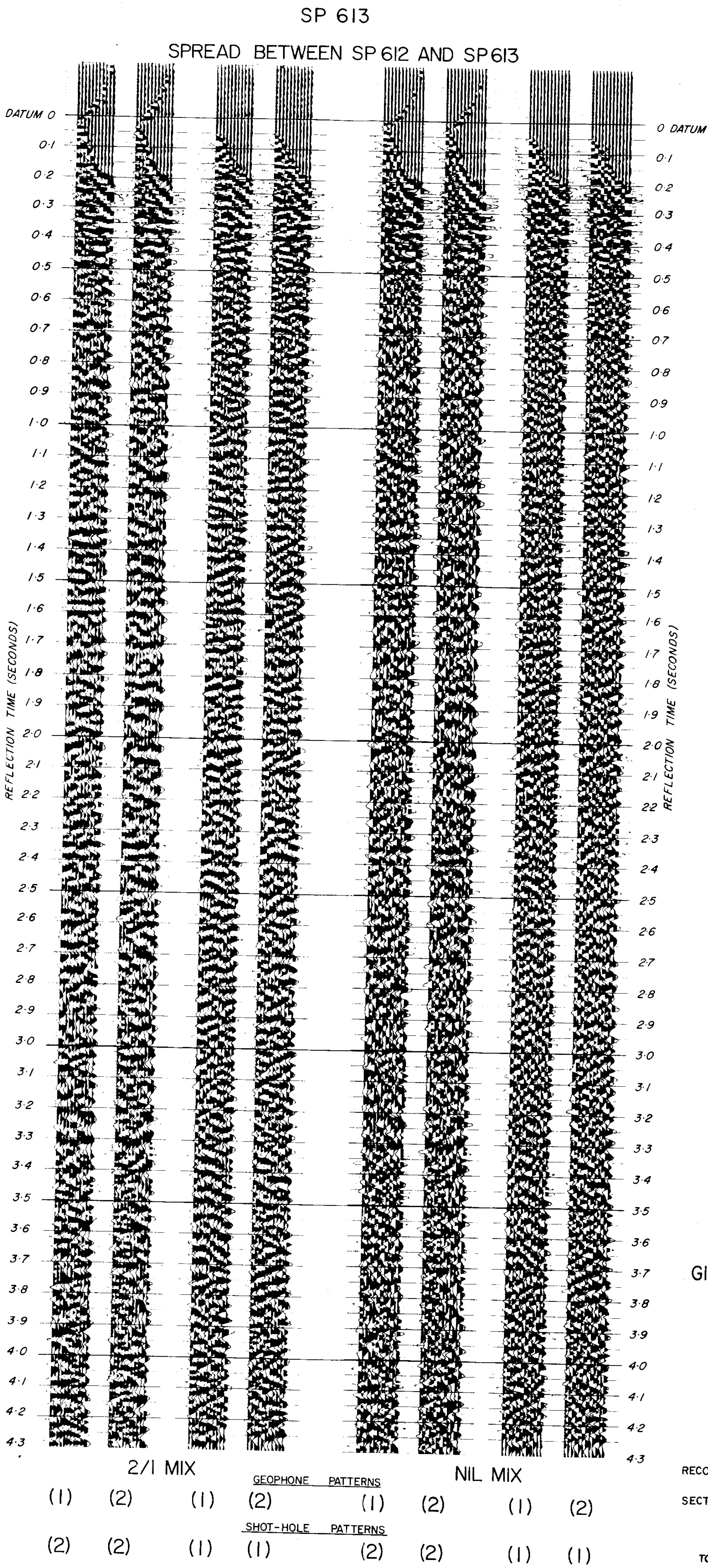
## GEOPHONE AND SHOT - HOLE PATTERN COMPARISONS

RECORDED BY : *Seismic Party No. 2*

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

G51/B3-20

TO ACCOMPANY RECORD No. 1967/123




# CORRECTED RECORD SECTION

RECORDING INFORMATION

*Magnetic Recorder:* DS7-700

*Amplifiers:* 7000B

*Filters:* K18-K66

*A.G.C.:* Wide Band

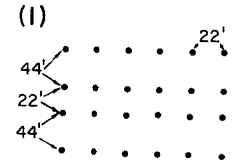
*Gain Initial:* -50

*Final:* Max

*Geophones:* EVS 2B-20 c/s

*Geophone pattern:*

(1)



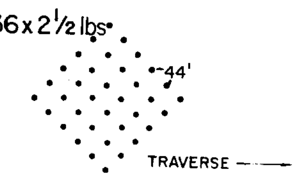

(2) 6/Trace, 22' apart in line

Station interval 150'

*Shot-hole pattern:*

(1) Single hole, Depth 82', Charge 40 lbs

(2) Depth 18', Charge 36 x 2½ lbs




PLAYBACK INFORMATION

*Filters:* 1/25-1/60

*A.G.C.:* S.S.

*Gain Initial:* -50

*Final:* -30

*Trip delay:* 0

*Compositing:* as indicated

VELOCITY INFORMATION

$t^2 : x^2$

at SP 714 Mount Beadell traverse

HORIZONTAL SCALE

FEET

0 900 1800 2700 3600 4500

GILES-CARNEGIE SEISMIC SURVEY, 1962

## MOUNT EVERARD TRAVERSE

GEOPHONE AND SHOT-HOLE PATTERN COMPARISONS

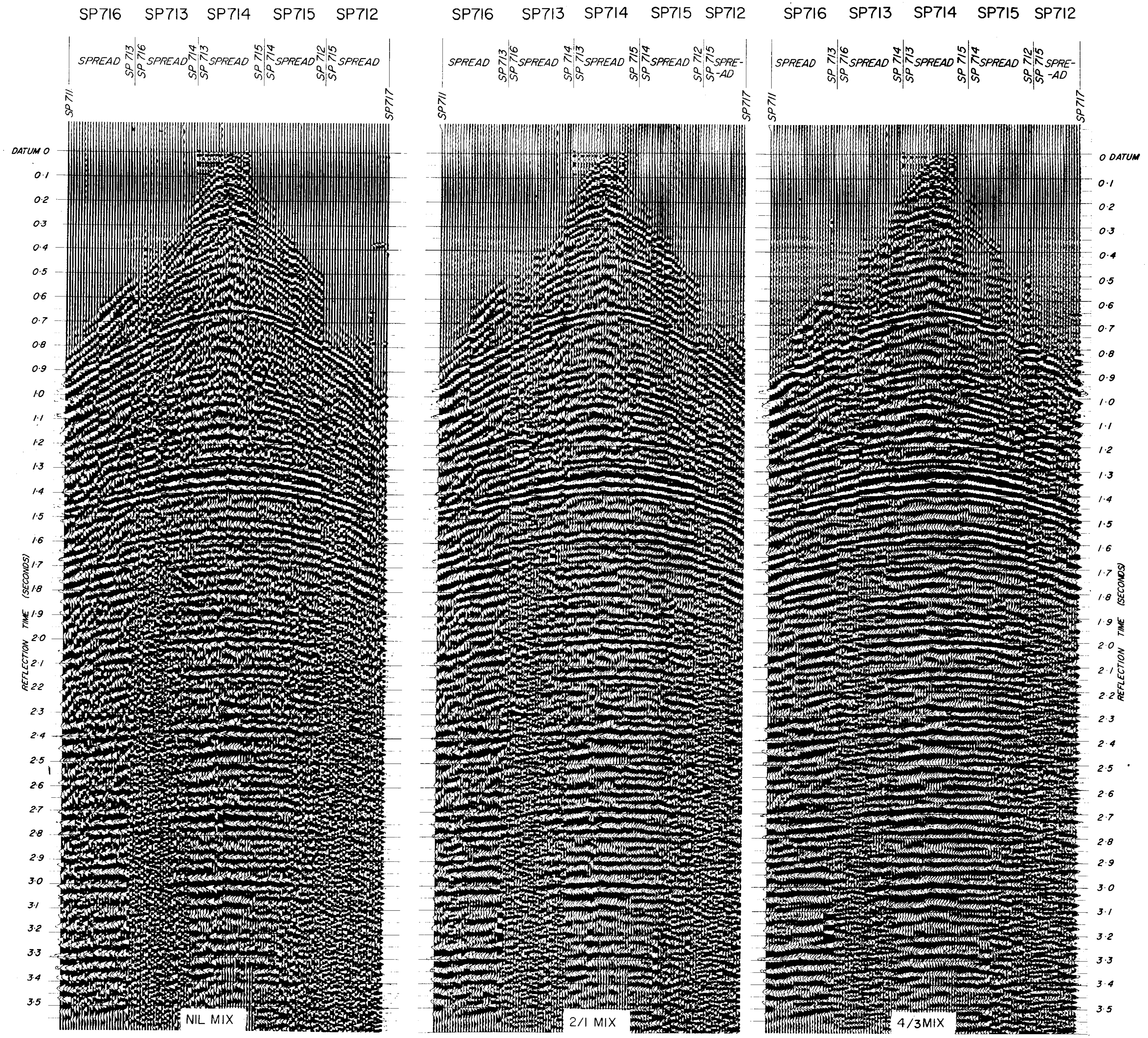
RECORDED BY: *Seismic Party No. 2*

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

G51/B3-21

TO ACCOMPANY RECORD No 1967 / 123

**PLATE 12**




*NOTE: RH. 6 traces damaged in playback centre*

## CORRECTED RECORD SECTION

( STATIC CORRECTIONS ONLY )

**RECORDING INFORMATION**

*Magnetic Recorder* E.T.L. DS7 / 700

*Amplifiers:* T.I. 7000B

*Filters:* K18 – K66

*A.G.C.:* WB

*Gain Initial:* -50

*Final:* Max

*Geophones:* E.T.L. EVS2B, 20 c/s

*Geophone pattern:*

22' 44' 22' 44'

*Shot-hole pattern:*

44'

**PLAYBACK INFORMATION**

*Filters:* 1/25 – 1/60

*A.G.C.:* Super slow

*Gain Initial:* -30

*Final:* -10

*Trip delay:* —

*Compositing:* As indicated

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET

0 1320 2640

GILES - CARNEGIE SEISMIC SURVEY, 1962
MOUNT BEADELL TRAVERSE

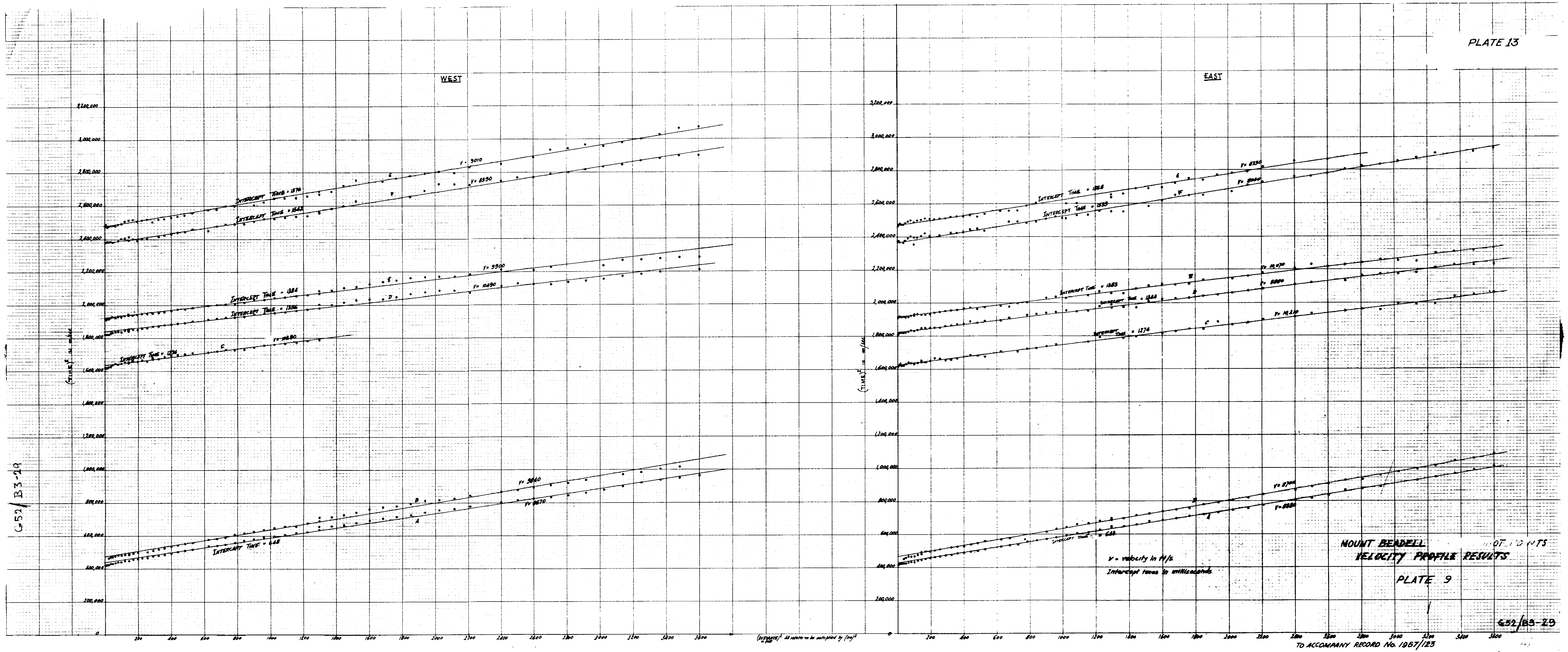
EXPANDED - SPREAD
VELOCITY SHOOT

RECORDED BY: *Seismic Party No. 2*

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

G51 / B3-16

TO ACCOMPANY RECORD No. 1967/123

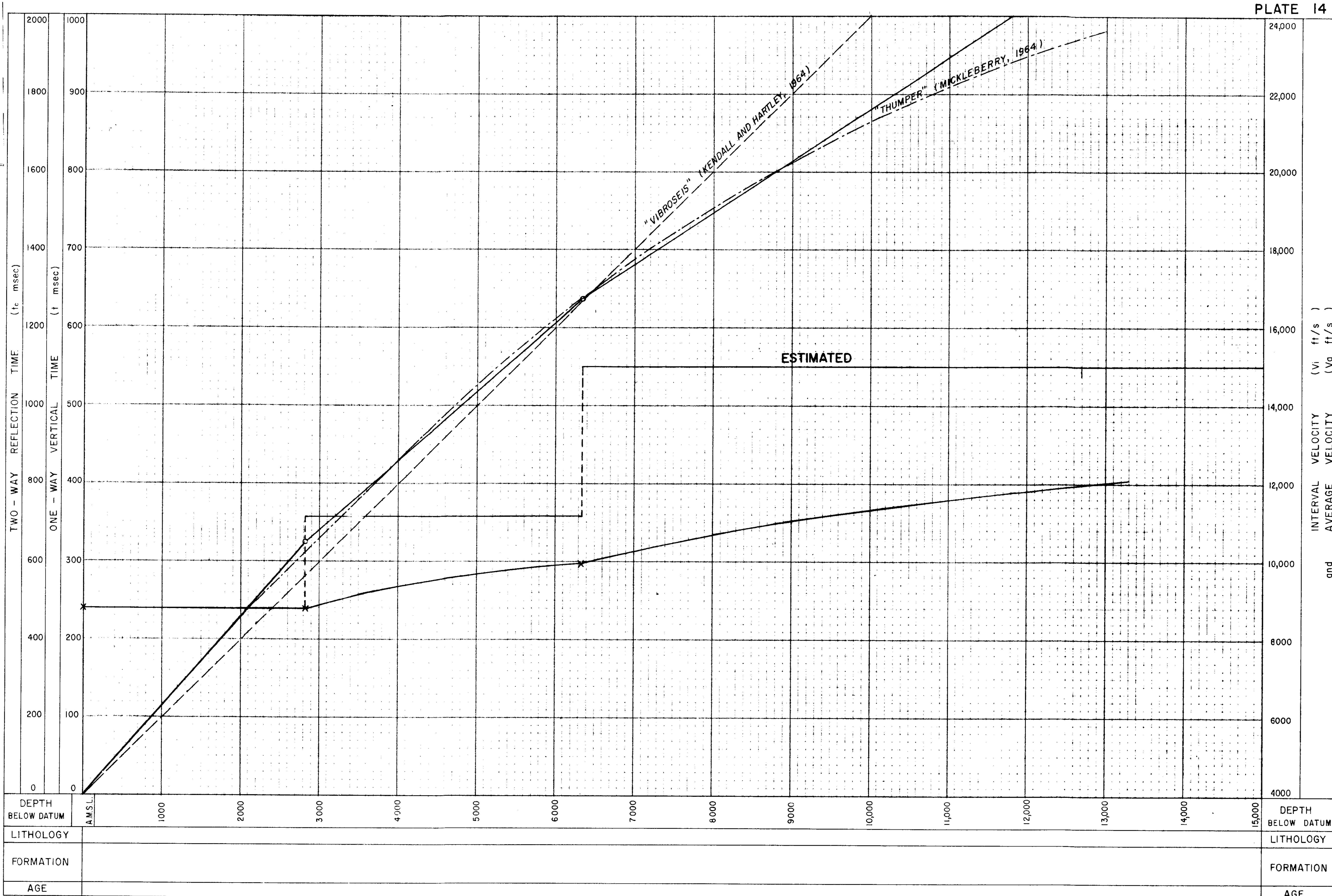



MOUNT BEADELL
VELOCITY PROFILE RESULTS
PLATE 9

G52/B3-29

TO ACCOMPANY RECORD No. 1967/123

PLATE 14




(Based on G 85/3-21)

LITHOLOGY

Time- Depth Curve ($t$-$d$)
Interval Velocity ($V_i$)
Average Velocity ($V_a$)

Sandstone
Siltstone
Shale
Limestone

# VELOCITY AND TIME VERSUS DEPTH

AREA MOUNT BEADELL (GILES-CARNEGIE, 1962)

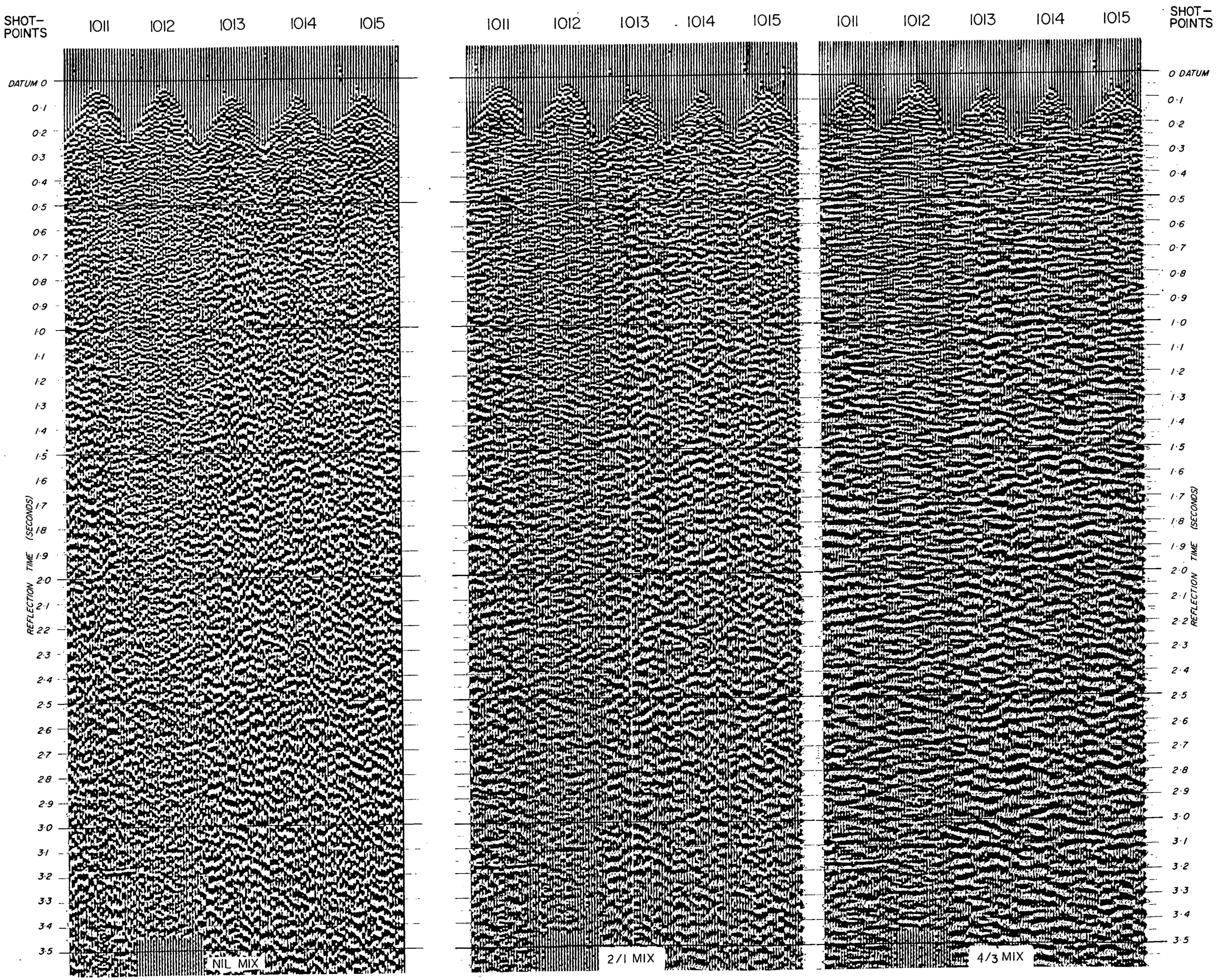
Basis Extended spread velocity shoot (Estimated below 6340 ft)

TO ACCOMPANY RECORD No. 1967/123

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G52/B 3-31

**PLATE 15**

# CORRECTED RECORD SECTION




*NOTE: The trace polarity in the mixed sections is reversed*

RECORDING INFORMATION

*Magnetic Recorder* E.T.L. DS7/700

*Amplifiers:* T.I. 7000B

*Filters:* K18 - K75

*A.G.C.:* W.B.

*Gain Initial:* -60

*Final:* -30 dB

*Geophones:* E.T.L. EVS 2B, 20 c/s

*Geophone pattern:*

6 per trace, 22 ft apart in line
Station interval 110 ft

*Shot-hole pattern:*

Single hole
Depth: 52 to 100 ft
Charge: 5, 10 lbs Geophex

PLAYBACK INFORMATION

*Filters:* 1/25 - 1/60

*A.G.C.:* Super slow

*Gain Initial:* -50

*Final:* -30

*Trip delay:* -2

*Compositing:*

See sections

VELOCITY INFORMATION

$t^2 : x^2$
at SP714 Mount Beadell traverse
(adjusted)

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1320 2640

GILES-CARNEGIE SEISMIC SURVEY, 1961

# MOUNT CHARLES TRAVERSE

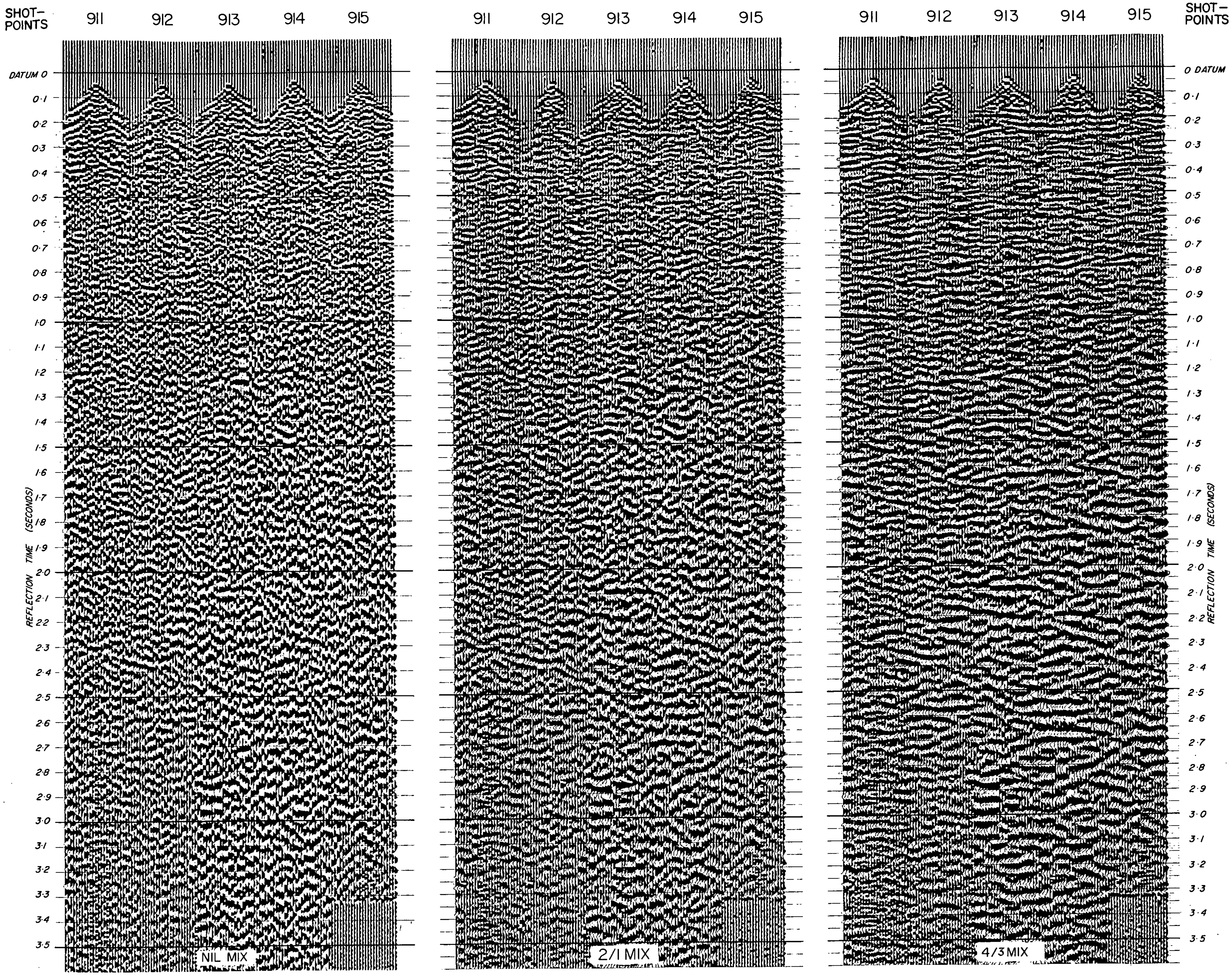
RECORDED BY: *Seismic Party No. 2*

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

G51/B3-13

TO ACCOMPANY RECORD No. 1967/123

**PLATE 16**




*NOTE: The trace polarity in the mixed sections is reversed*

# CORRECTED RECORD SECTION

## RECORDING INFORMATION

*Magnetic Recorder* E.T.L. DS7/700

*Amplifiers:* T.I. 7000B

*Filters:* K18-K 75

*A.G.C.:* W.B.

*Gain Initial:* -60

*Final:* -30 dB

*Geophones:* E.T.L. EVS 2B, 20 c/s

*Geophone pattern:*

6 per trace, 22 ft apart in line
Station interval 110 ft

*Shot-hole pattern:*

Single hole
Depth: 68 to 86 ft
Charge: 5, 10 lbs Geophex

## PLAYBACK INFORMATION

*Filters:* 1/25 - 1/60

*A.G.C.:* Super slow

| | | Unmixed | Mixed |
|---|---|---|---|
| *Gain* | *Initial:* | -50 | -40 |
| | *Final:* | -30 | -20 |

*Trip delay:* -2

*Compositing:*

See sections

## VELOCITY INFORMATION

$t^2 : x^2$
at SP714 Mount Beadell traverse
(adjusted)

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1320 2640

GILES - CARNEGIE SEISMIC SURVEY, 1961

# MOUNT SAMUEL TRAVERSE

RECORDED BY: *Seismic Party No. 2*

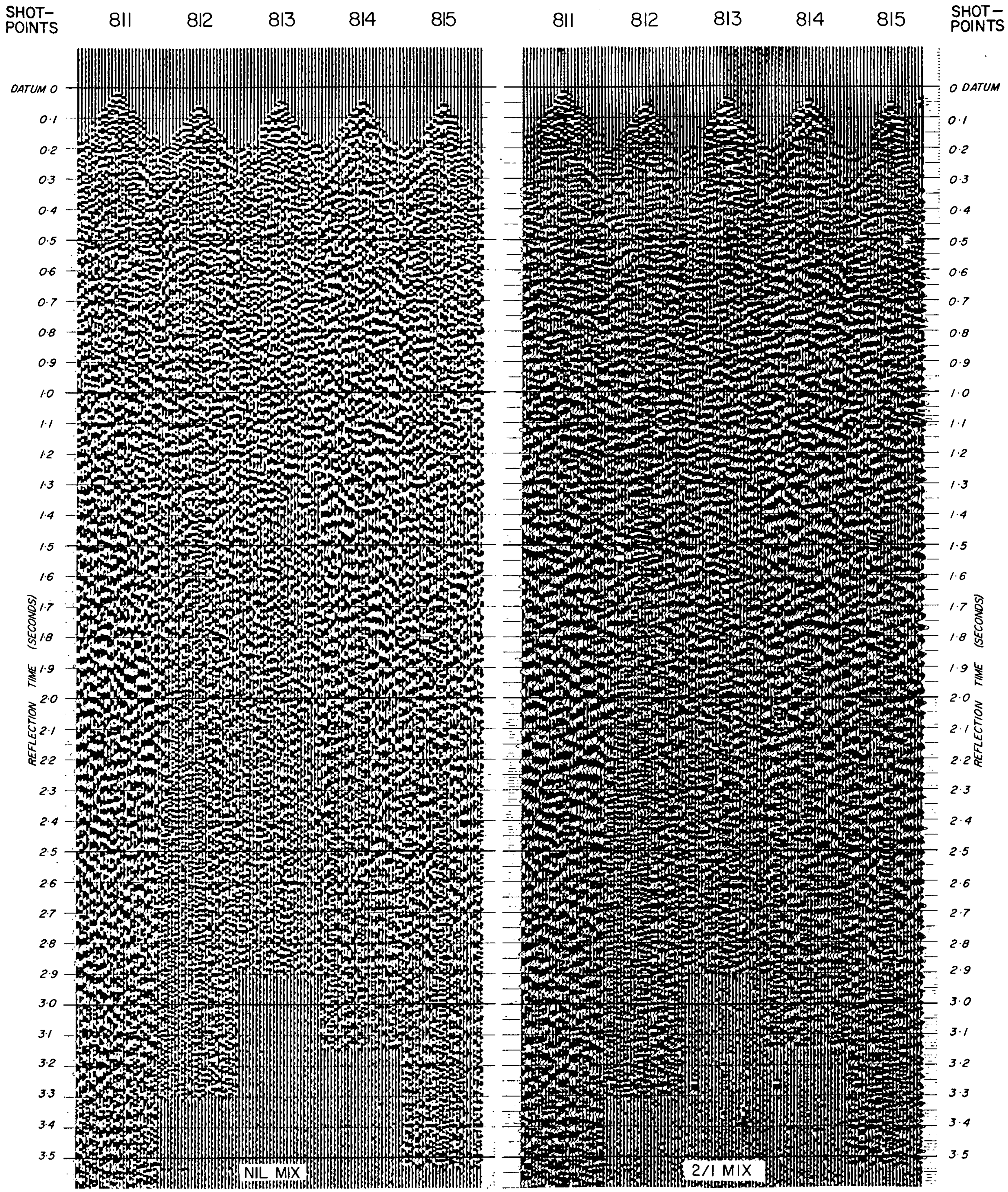
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42*

G51/B3-15

TO ACCOMPANY RECORD No.1967/123

PLATE 17

# CORRECTED RECORD SECTION




*NOTE: The trace polarity on the mixed section is reversed*

## RECORDING INFORMATION

*Magnetic Recorder* E.T.L. DS7/700

*Amplifiers:* T.I. 7000 B

*Filters:* K18 K75

*A.G.C.:* W.B.

*Gain Initial:* -40, -50, -60

*Final:* -30 dB

*Geophones:* E.T.L. EVS 2B, 20 c/s

*Geophone pattern:*

6 per trace, 22 ft apart in line
Station interval 110 ft

*Shot-hole pattern:*

Single hole
Depth 72 ft – 116 ft
Charge 5, 10, 15 lb Geophex

## PLAYBACK INFORMATION

*Filters:* 1/25 – 1/60

*A.G.C.:* Super slow

*Gain Initial:* -50

*Final:* -30

*Trip delay:* -2

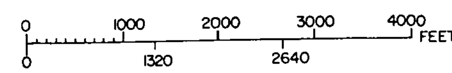
*Compositing:* See sections

## VELOCITY INFORMATION

$t^2 : x^2$

at SP 714 Mount Beadell traverse

HORIZONTAL SCALE




GILES-CARNEGIE SEISMIC SURVEY, 1961

## NMF 19 TRAVERSE

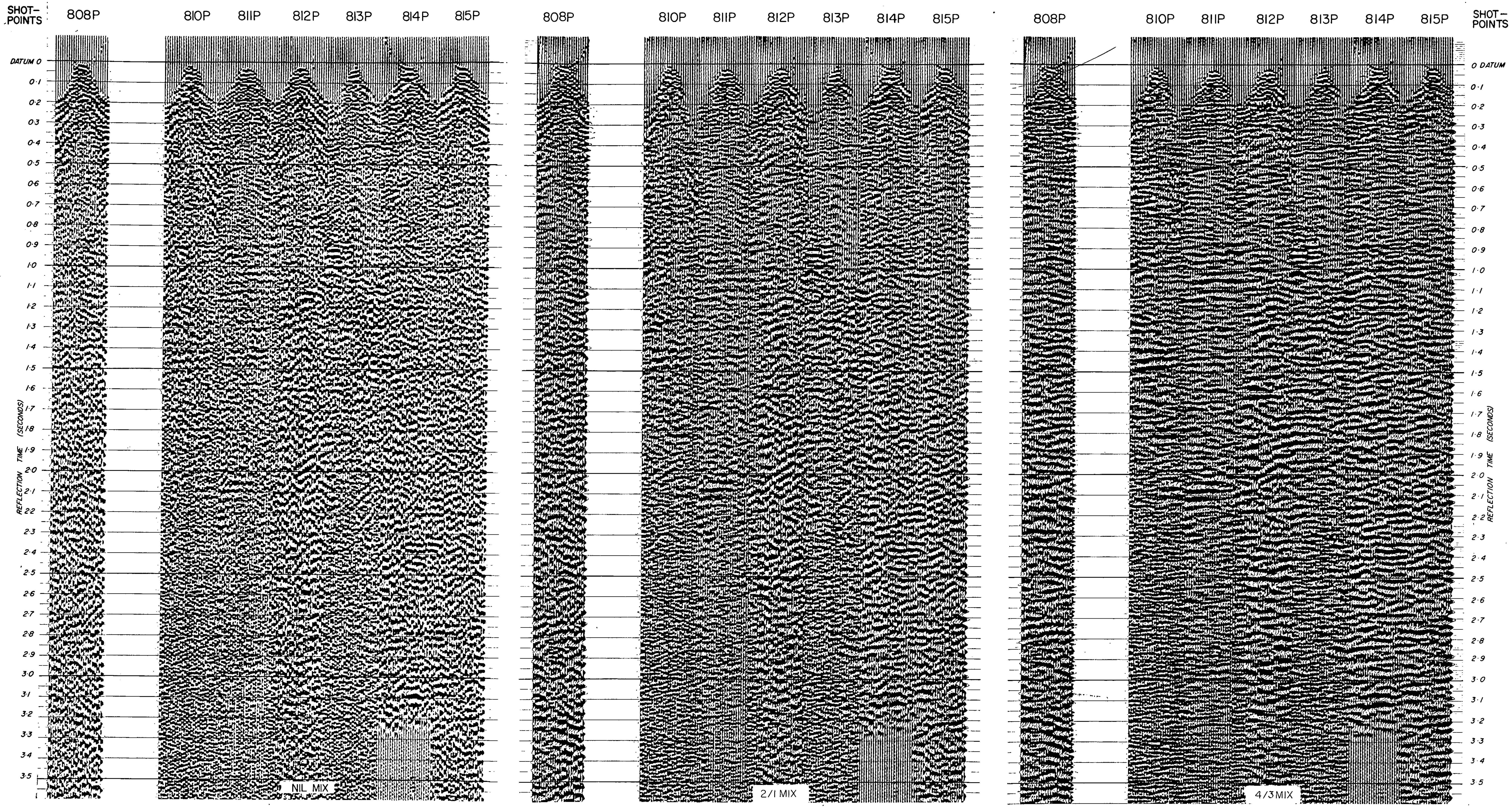
RECORDED BY: *Seismic Party No. 2*

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

G51/B3-11

TO ACCOMPANY RECORD. No. 1967/123

PLATE 18




NOTE : The trace polarity on the mixed sections is reversed

# CORRECTED RECORD SECTION

RECORDING INFORMATION

*Magnetic Recorder* E.T.L. DS7/700

*Amplifiers* : T.I. 7000B

*Filters* : K18 to K66

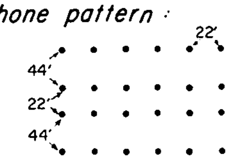
*A.G.C.* : W.B.

*Gain Initial* : -40, -50

*Final* : Max

*Geophones* : E.T.L. EVS 2B 20 c/s

*Geophone pattern* :




*Shot-hole pattern* :

7 holes 44 ft apart in line

Depth 80 ft

Charge 7 x 2½ lbs Geophex

PLAYBACK INFORMATION

*Filters* : 1/25 - 1/60

*A.G.C.* : Super slow

*Gain Initial* : -40

*Final* : -20

*Trip delay* : -2

*Compositing* :

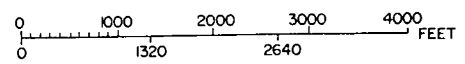
See sections

VELOCITY INFORMATION

$t^2 : x^2$

at SP 714 Mount Beadell traverse

HORIZONTAL SCALE




GILES-CARNEGIE SEISMIC SURVEY, 1962

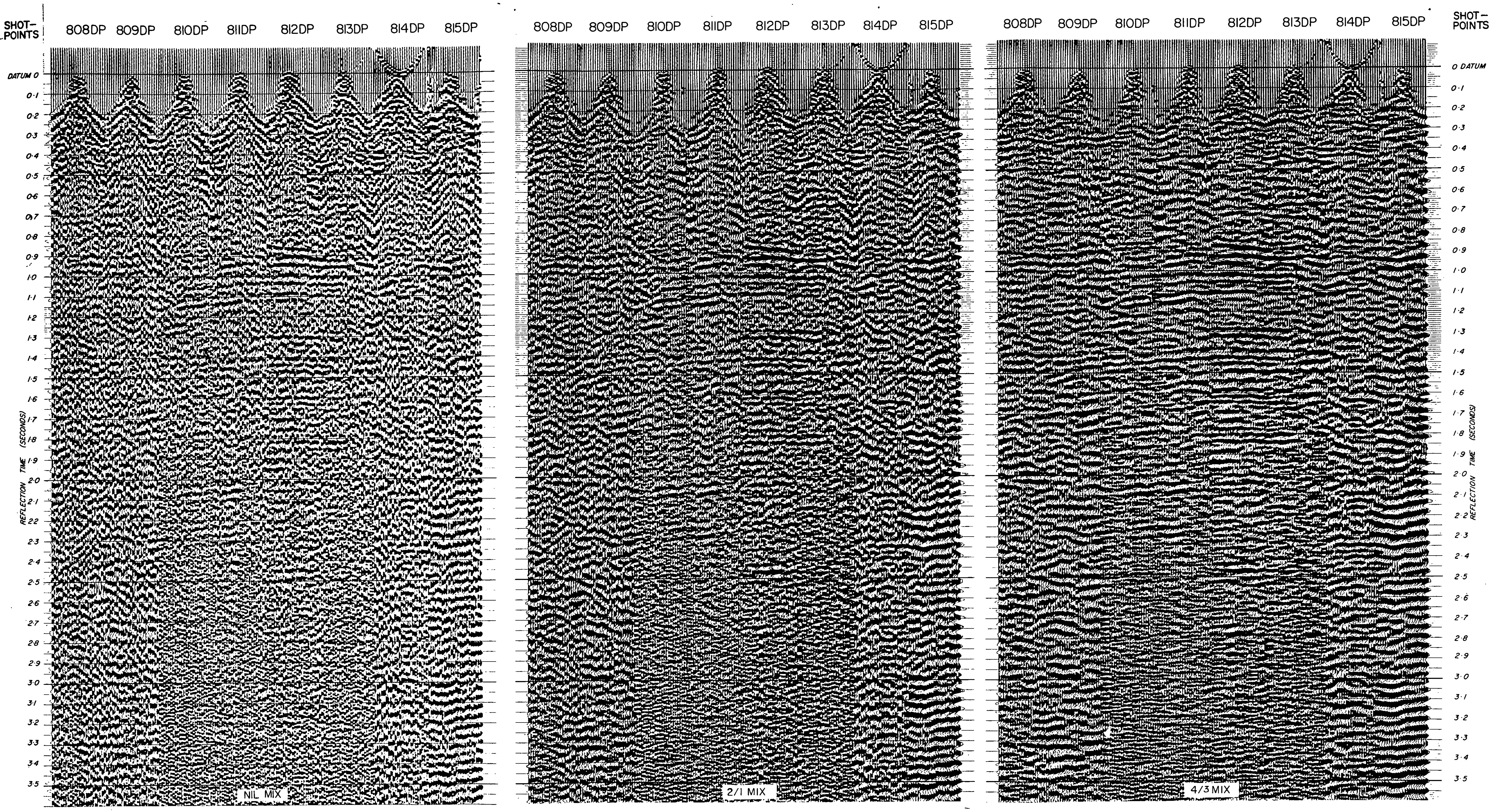
## NMF 19 TRAVERSE

RECORDED BY: *Seismic Party No. 2*

SECTION BY: *Bureau of Mineral Resources*
*Playback Centre S/E MS 42*

G51/B3-11-2

TO ACCOMPANY RECORD No. 1967/123




NOTE : The trace polarity on the mixed sections is reversed

## CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder E.T.L. DS7/700

Amplifiers : T.I. 7000 B

Filters : K18 to K66

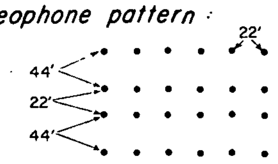
A.G.C. : W.B.

Gain Initial : -50

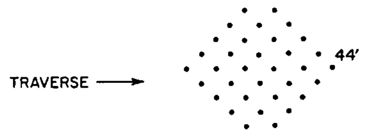
Final : Max

Geophones : E.T.L. EVS2B 20 c/s

Geophone pattern :




Shot-hole pattern :




Depth 13 ft

Charge 36 x 2/3 lb

PLAYBACK INFORMATION

Filters : 1/25 - 1/60

A.G.C. : Super slow

Gain Initial : -40

Final : -20

Trip delay : -2

Compositing :

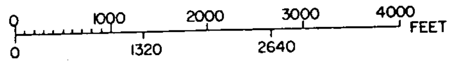
See sections

VELOCITY INFORMATION

$t^2 : x^2$

at SP714 Mount Beadell traverse

HORIZONTAL SCALE




GILES-CARNEGIE SEISMIC SURVEY, 1962

## NMF 19 TRAVERSE

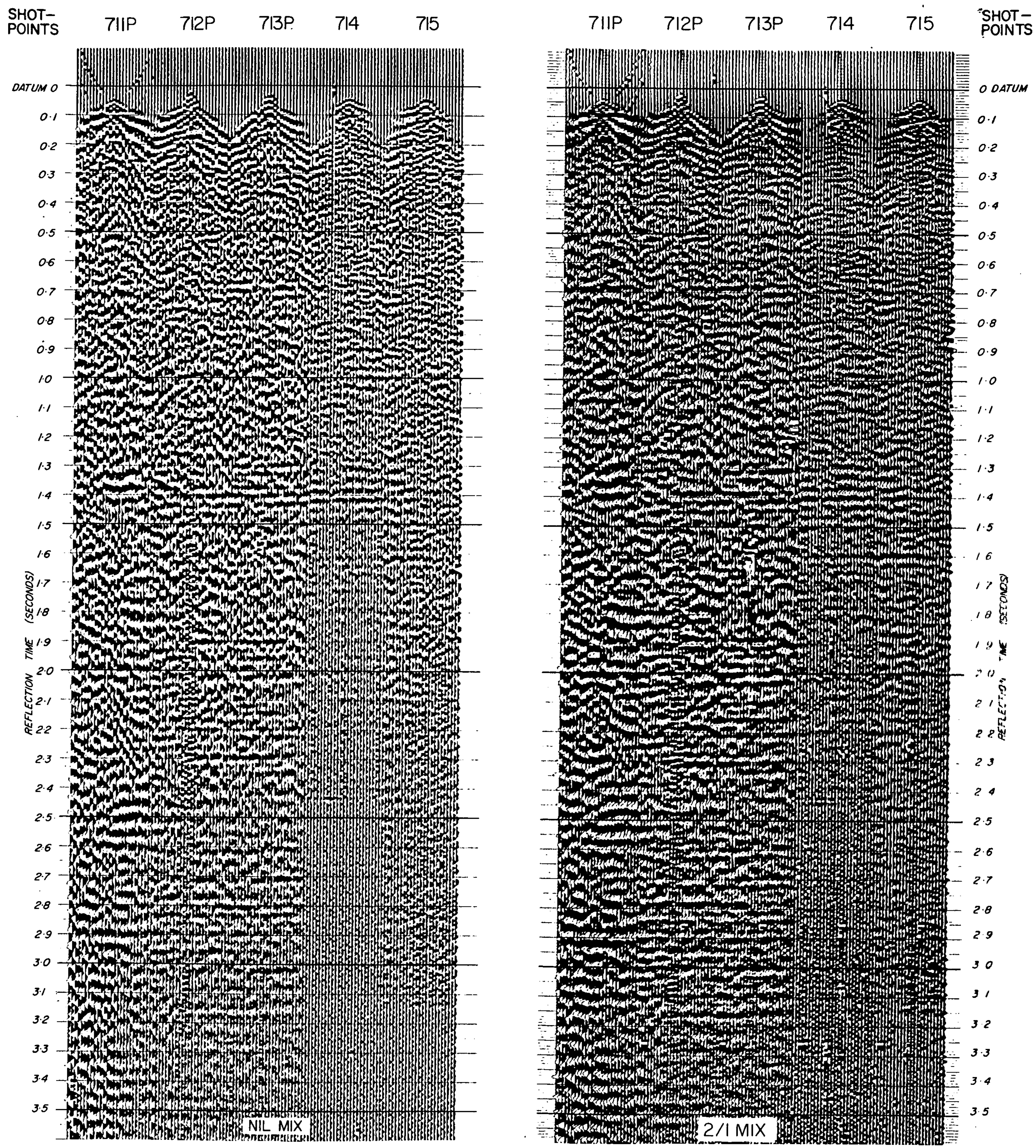
RECORDED BY : Seismic Party No. 2

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

G51/B3-11-3

TO ACCOMPANY RECORD No. 1967/123

# CORRECTED RECORD SECTION




NOTE: The trace polarity on the mixed section is reversed

RECORDING INFORMATION

*Magnetic Recorder* E.T.L. DS7/700

*Amplifiers:* T.I. 7000B

*Filters:* K18 K75

*A.G.C.:* W.B.

*Gain Initial:* -50, -60

*Final:* -30 Dbs

*Geophones:* E.T.L. EVS 2B, 20 c/s

*Geophone pattern:*

6 per trace, 22 ft apart in line

Station interval 110 ft

*Shot-hole pattern:*

711, 712, 713 — Depth 6 ft, Charge 9 x 2½ lbs

714, 715 — Single hole, Depth 80 ft, Charge 10 lbs

50'

PLAYBACK INFORMATION

*Filters:* 1/25 - 1/60

*A.G.C.:* Super slow

*Gain Initial:* -40

*Final* -20

*Trip delay* 2

*Compositing:*

See sections

VELOCITY INFORMATION

$t^2 : x^2$ at SP714

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET

0 1320 2640

GILES - CARNEGIE SEISMIC SURVEY, 1961

MOUNT BEADELL TRAVERSE

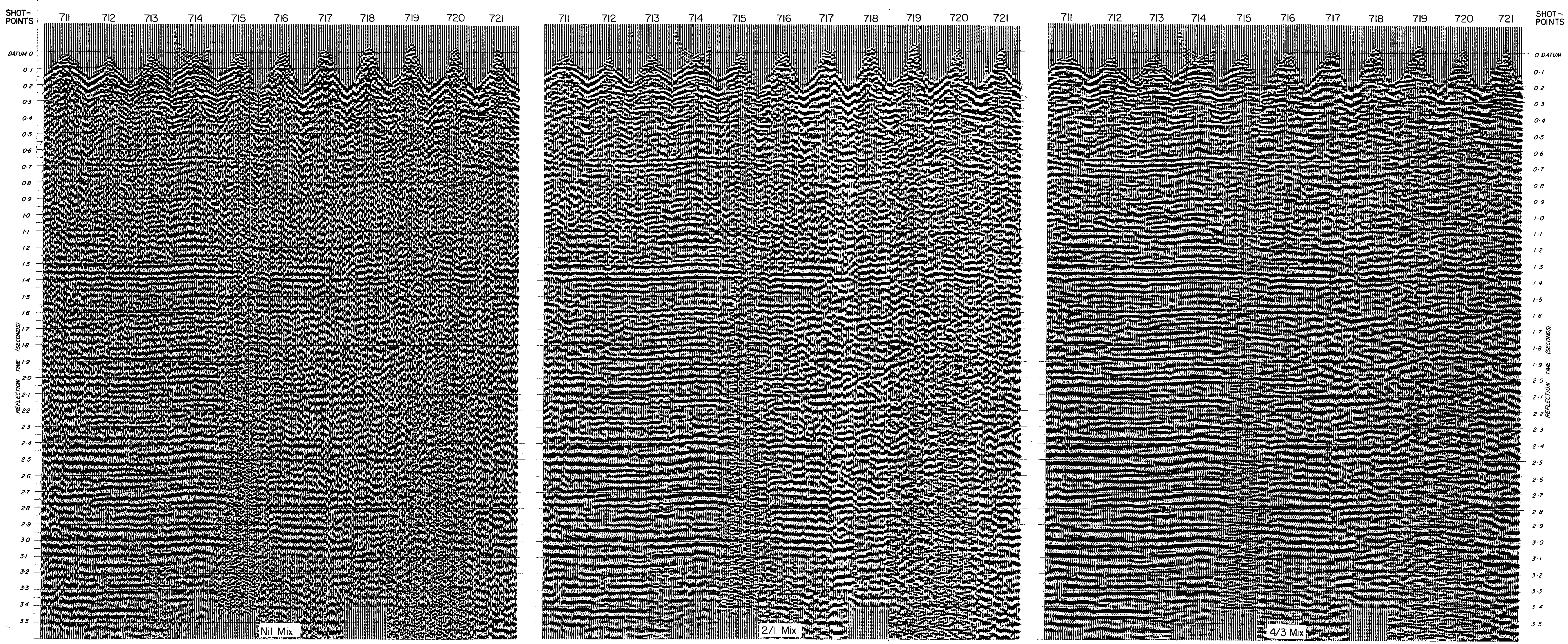
RECORDED BY: *Seismic Party No. 2*

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

G51/B3-12-1

TO ACCOMPANY RECORD No.1967/123

# PLATE 21




## CORRECTED RECORD SECTION

**RECORDING INFORMATION**

*Magnetic Recorder* E.T.L. DS7/700

*Amplifiers:* T.I. 7000B

*Filters:* K18-K66

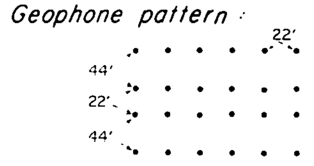
*A.G.C.:* W.B.

*Gain Initial:* -50

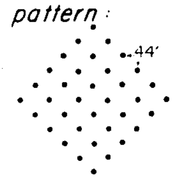
*Final:* Max.

*Geophones:* E.T.L. EVS 2B 20 c/s

*Geophone pattern:*




*Shot-hole pattern:*




Depth 13ft

Charge 36 x 2/3 lb

**PLAYBACK INFORMATION**

*Filters:* L 25 - L 60

*A.G.C.:* Super slow

*Gain Initial:* -40

*Final:* -20

*Trip delay:* -2

*Compositing:*

See sections

**VELOCITY INFORMATION**

$t^2 : x^2$ at SP714

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET

0 1320 2640

GILES - CARNEGIE SEISMIC SURVEY, 1962

# MOUNT BEADELL TRAVERSE

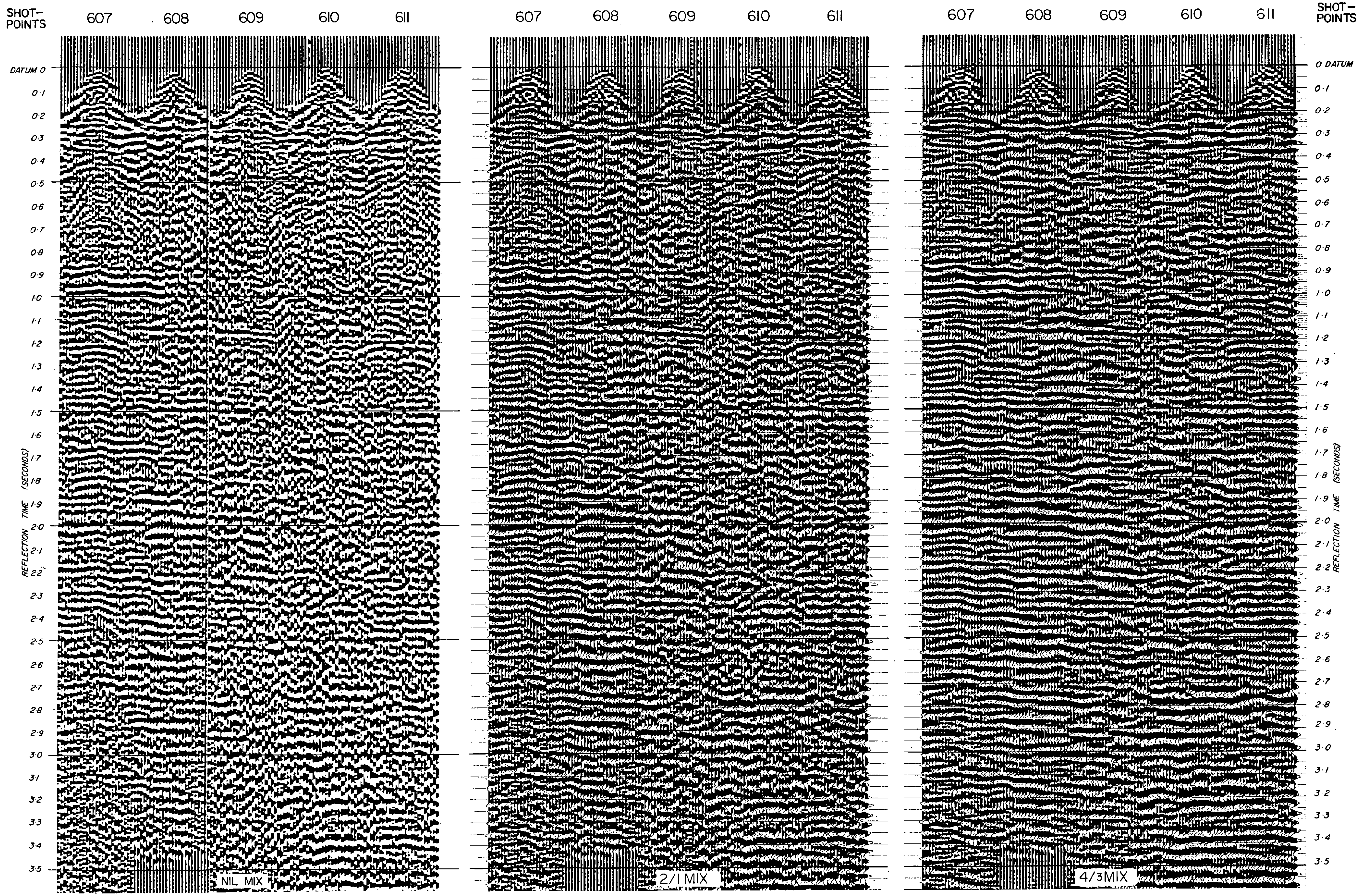
RECORDED BY *Seismic Party No. 2*

SECTION BY: *Bureau of Mineral Resources Playback Centre S/E MS 42*

G51/B3-12-2

TO ACCOMPANY RECORD No. 1967/123

# CORRECTED RECORD SECTION




*NOTE: The trace polarity on the mixed sections is reversed*

RECORDING INFORMATION

*Magnetic Recorder*: E.T.L. DS7/700

*Amplifiers*: T.I. 7000B

*Filters*: K18–K75

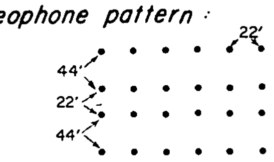
*A.G.C.*: W.B.

*Gain Initial*: −55

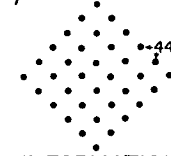
*Final*: Max

*Geophones*: E.T.L. EVS 2B, 20 c/s

*Geophone pattern*:




*Shot-hole pattern*:




TRAVERSE →

Depth 13 ft

Charge: 36 x 2½ lb

PLAYBACK INFORMATION

*Filters*: 1/25 – 1/60

*A.G.C.*: Super slow

*Gain Initial*: −40

*Final*: −20

*Trip delay*: −2

*Compositing*:

See sections

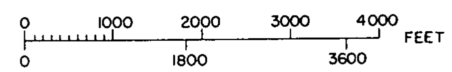
VELOCITY INFORMATION

$t^2 : x^2$

at SP714 Mount Beadell traverse

(adjusted)

HORIZONTAL SCALE



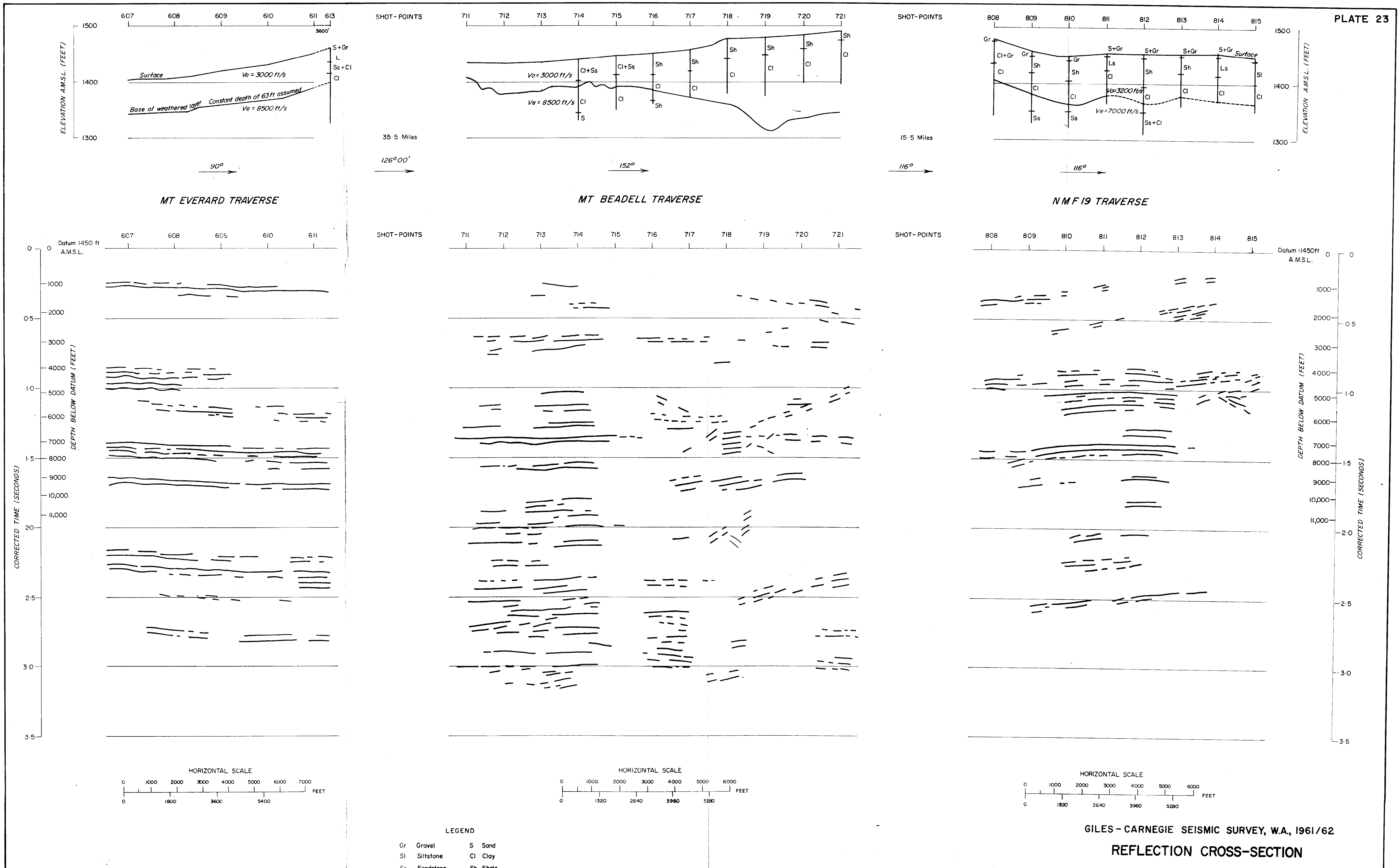

GILES–CARNEGIE SEISMIC SURVEY, 1962

## MOUNT EVERARD TRAVERSE

RECORDED BY: *Seismic Party No. 2*

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

G51/B3-14




GILES - CARNEGIE SEISMIC SURVEY, W.A., 1961/62

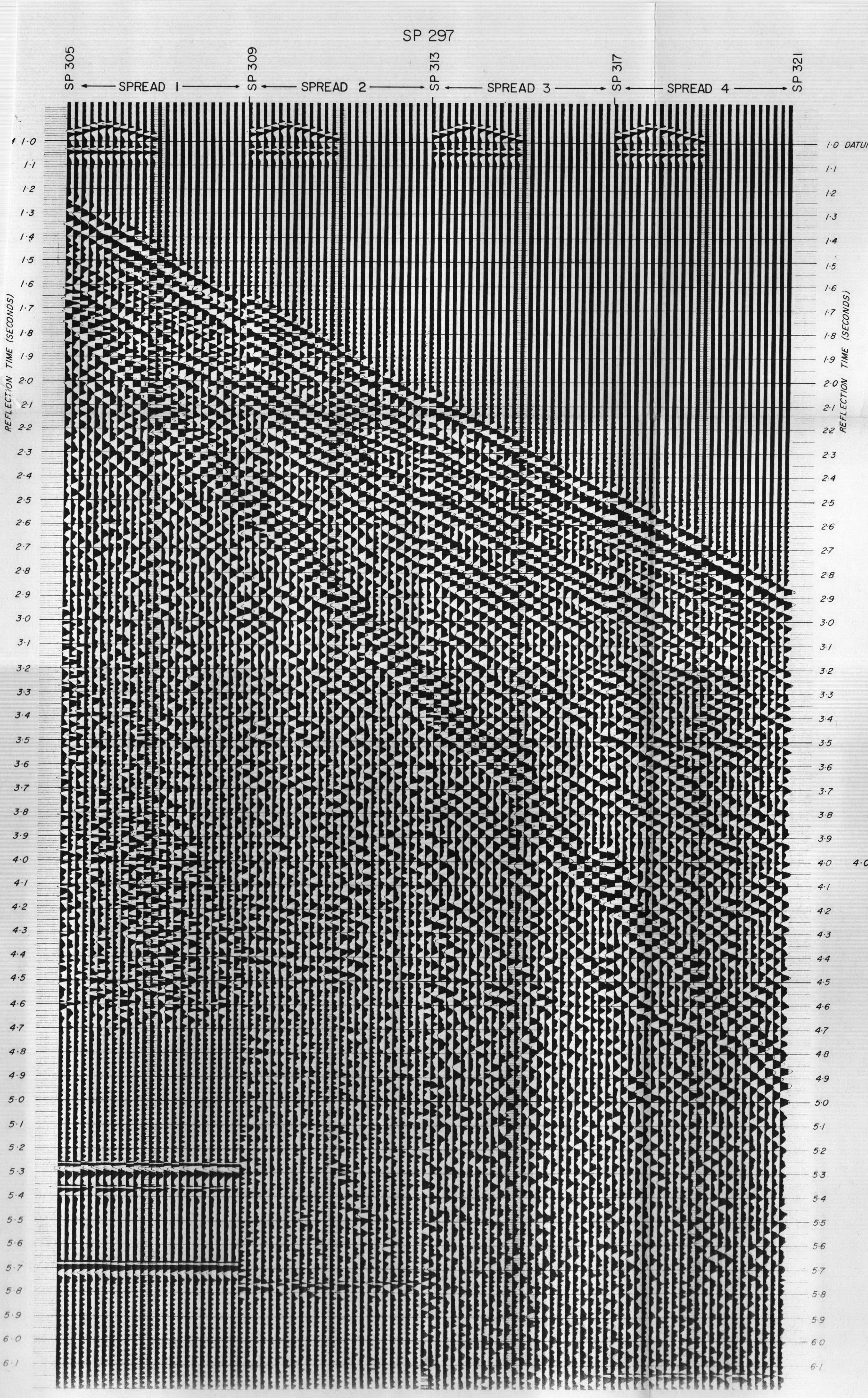
REFLECTION CROSS-SECTION

TO ACCOMPANY RECORD No. 1967/123

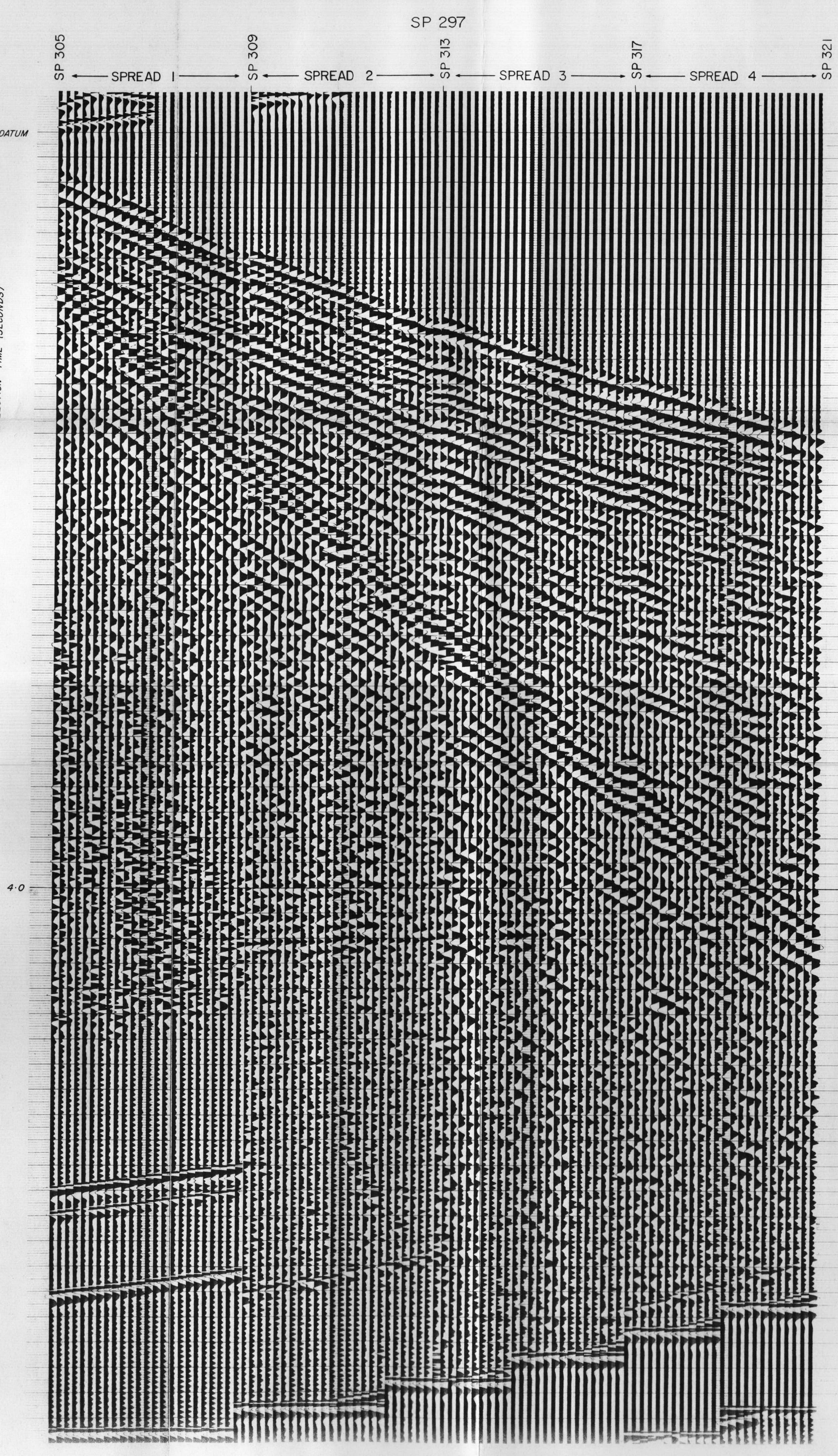
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

G51/B3-27

PLATE 24

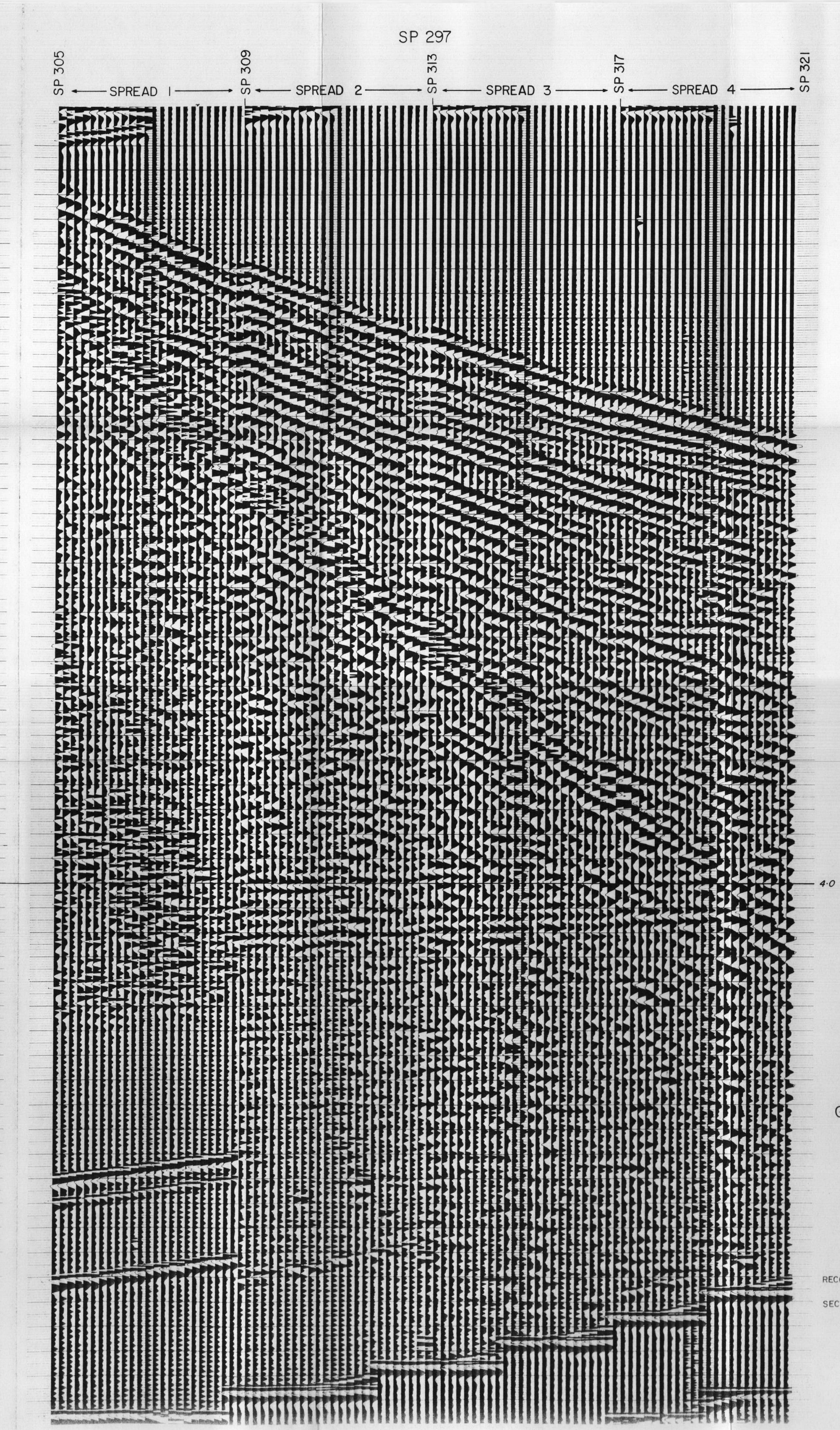



WEATHERING AND ELEVATION CORRECTIONS ONLY




WEATHERING AND ELEVATION CORRECTIONS PLUS
DYNAMIC CORRECTION AT 4·0 SECONDS APPLIED AS STATIC CORRECTION

NOTE: THE AMPLITUDES IN THE LEFT HAND SECTION ARE REVERSED FROM THOSE IN THE OTHER TWO SECTIONS




WEATHERING AND ELEVATION CORRECTIONS PLUS DYNAMIC
CORRECTION AT 4·0 SECONDS APPLIED AS STATIC CORRECTION
2/1 MIX

## CORRECTED RECORD SECTION

RECORDING INFORMATION

*Magnetic Recorder*: ETL DS7-700
*Amplifiers*: T.I. 7000 B
*Filters*: 0-K31, K40
*A.G.C.*: OUT
*Gain Initial*: / *Final*: -30, -40
*Geophones*: E.T.L. EVS 8B-45c/s
*Geophone pattern*:
4 geophones extended at 20 foot intervals normal to the traverse
*Shot-hole pattern*:
Single holes
Depth 35'-45'
60-200 lb Geophex

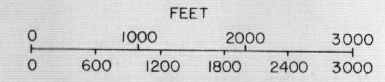
PLAYBACK INFORMATION

*Filters*: 2/16-1/78
*A.G.C.*: SS
*Gain Initial*: -50
*Final*: -30
*Trip delay*: 0 to 07s
*Compositing*:
As indicated

VELOCITY INFORMATION

Assumed Interval Velocity
Above 4500 ft - 13,600 ft/s
Below 4500 ft - 19,000 ft/s

HORIZONTAL SCALE



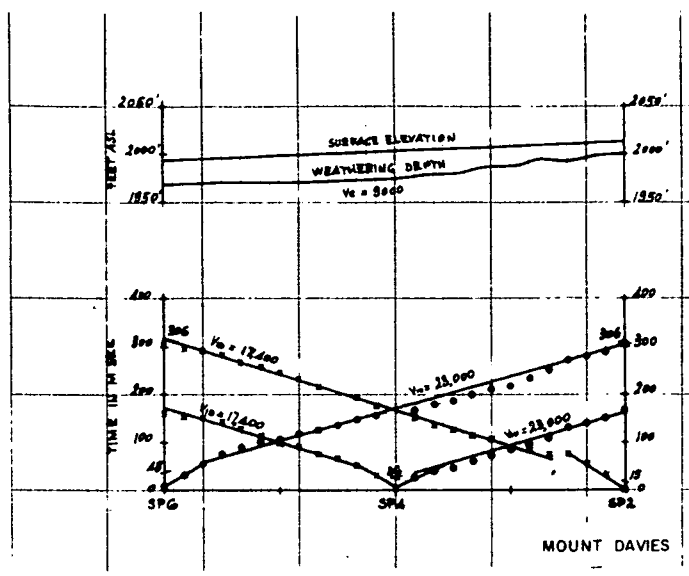

GILES-CARNEGIE SEISMIC SURVEY 1962

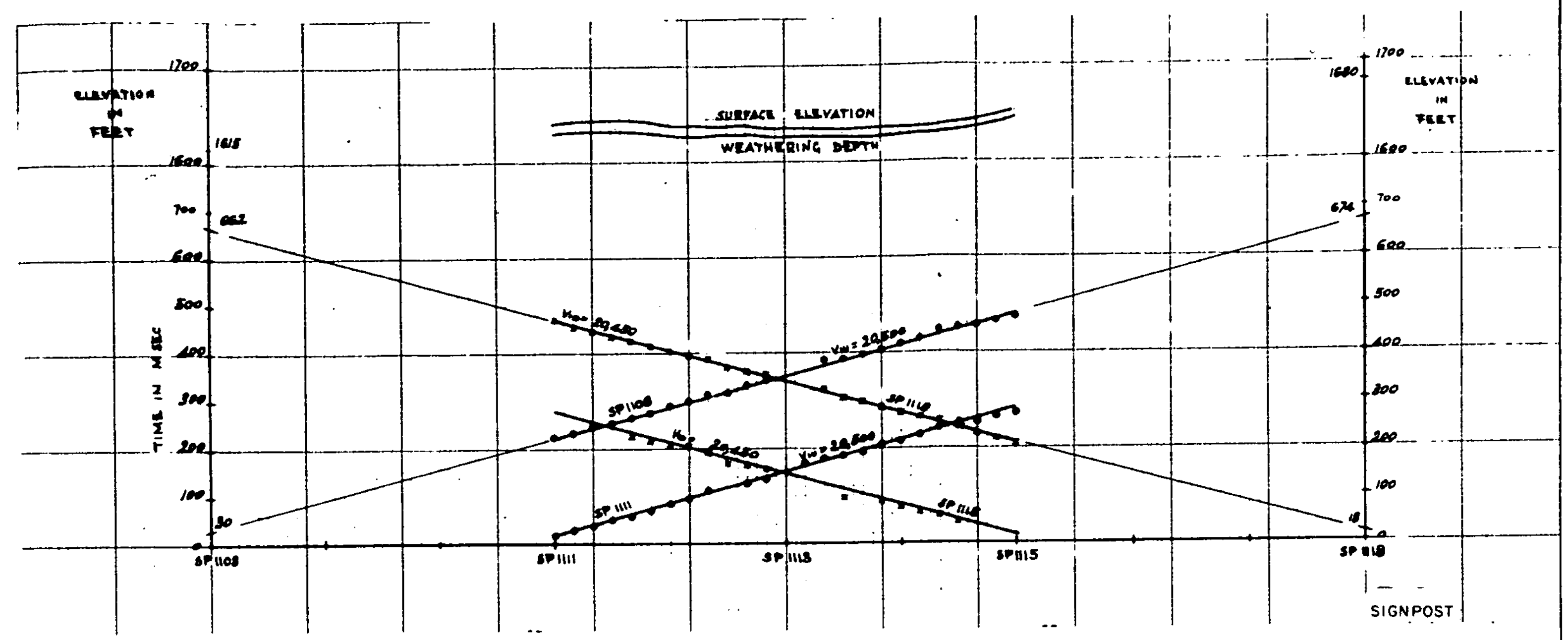
LAKE KEENE TRAVERSE

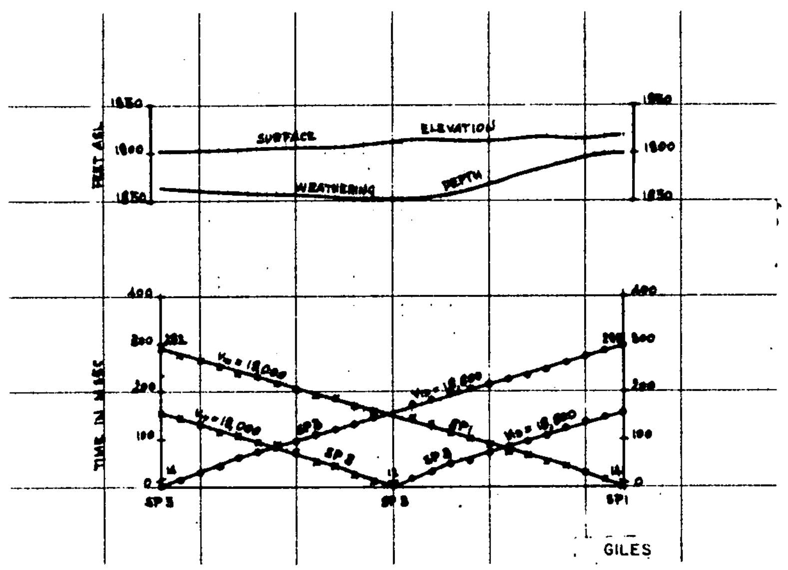
RECORDED BY: *Seismic Party No. 2*

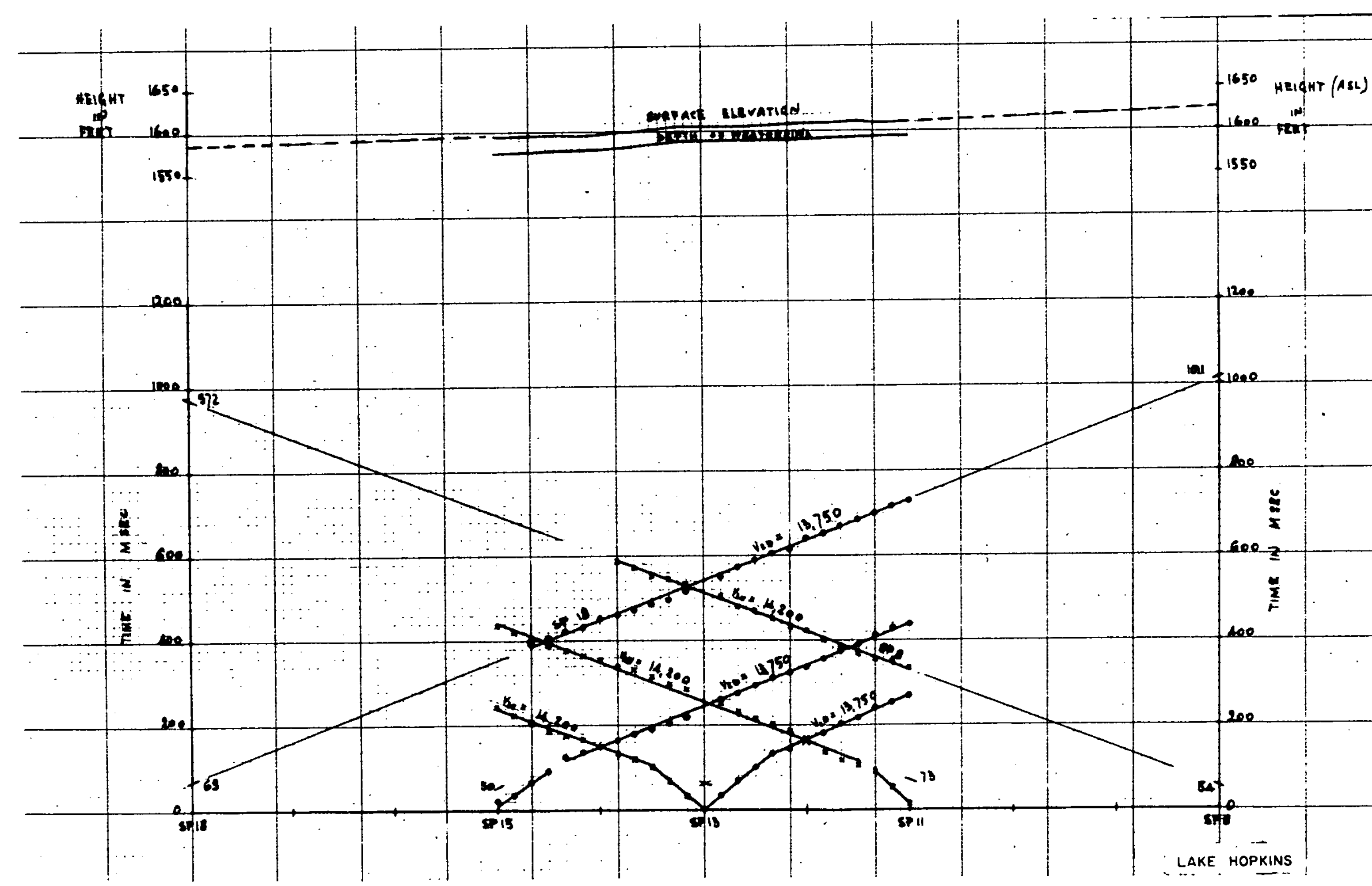
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* G51/B3-28

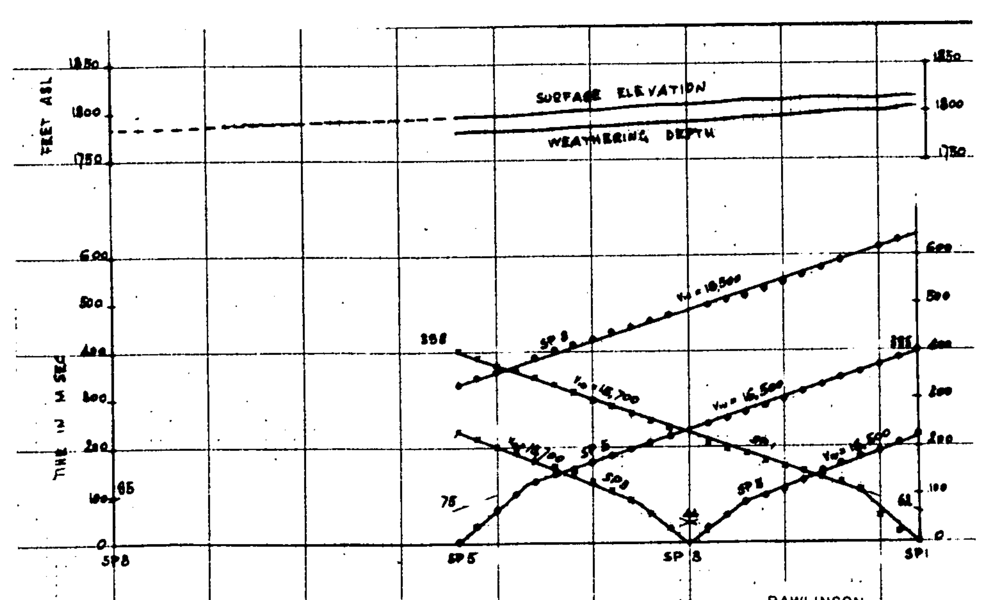
TO ACCOMPANY RECORD No 1967/123




REFRACTION TRAVERSES TIME / DISTANCE CURVES

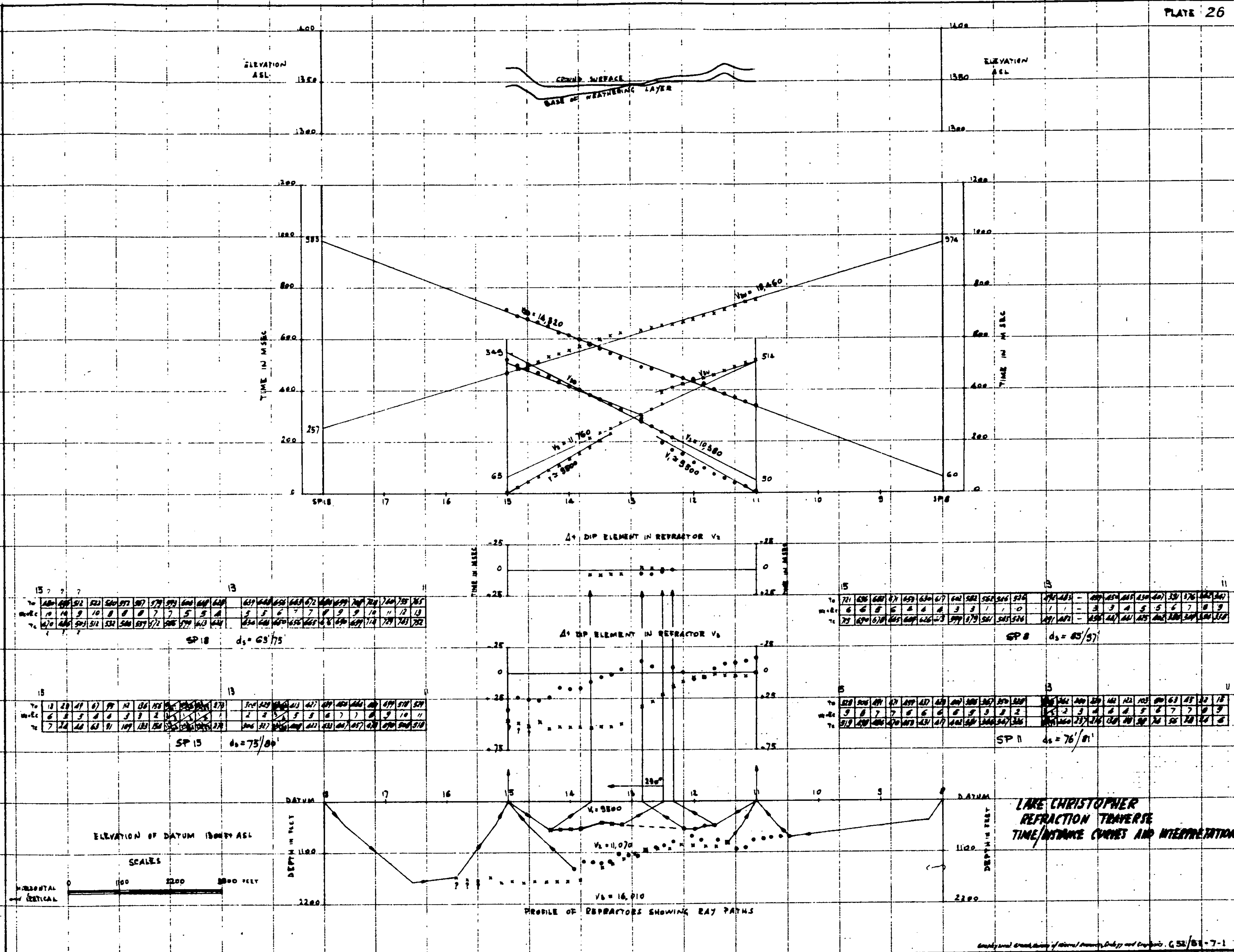
HORIZONTAL SCALE

1100 0 1100 2200 3300 FEET

NOTE: VELOCITIES IN FT/S

TO ACCOMPANY RECORD No. 1967/123

G52/B3-50




G 52/B1-7-1

and 1967/123

PLATE 27

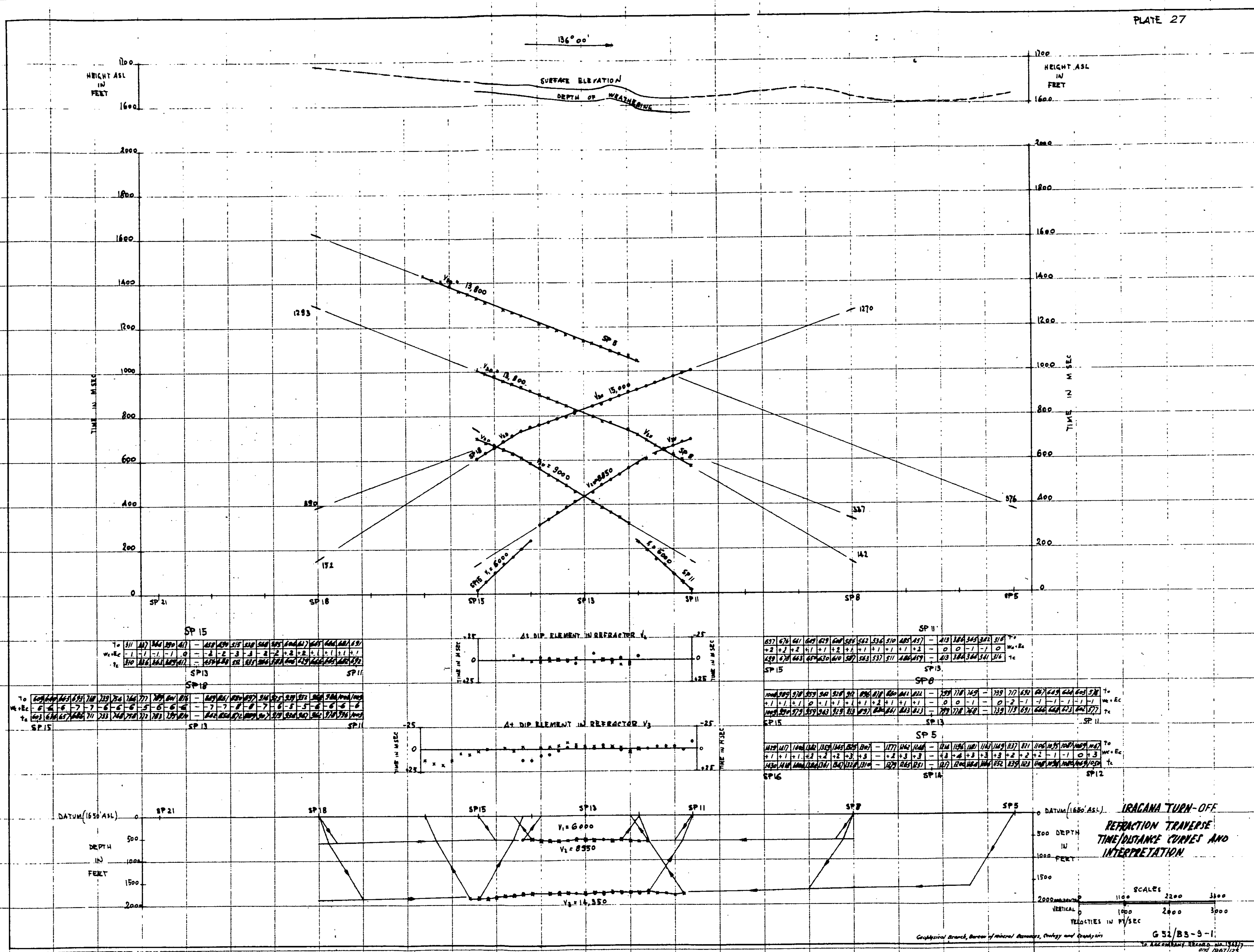

IRACANA TURN-OFF
REFRACTION TRAVERSE
TIME/DISTANCE CURVES AND INTERPRETATION
136° 00'
HEIGHT ASL IN FEET
SURFACE ELEVATION
DEPTH OF WEATHERING
TIME IN M SEC
SP 21
SP 18
SP 15
SP 13
SP 11
SP 8
SP 5
Δt DIP ELEMENT IN REFRACTOR $V_2$
Δt DIP ELEMENT IN REFRACTOR $V_3$
DATUM (1650' ASL)
DEPTH IN FEET
$V_1$ = 6000
$V_2$ = 8550
$V_3$ = 14,350
SCALES
VELOCITIES IN FT/SEC
G 52/B3-9-1
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics
To accompany Record No. 1963/? and 1967/125

PLATE 28


TO ACCOMPANY RECORD No. 1967/123

MT CHARLES REFRACTION TRAVERSE

GILES - CARNEGIE SURVEY 1962

## TIME / DISTANCE CURVES

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

G52/B3-24

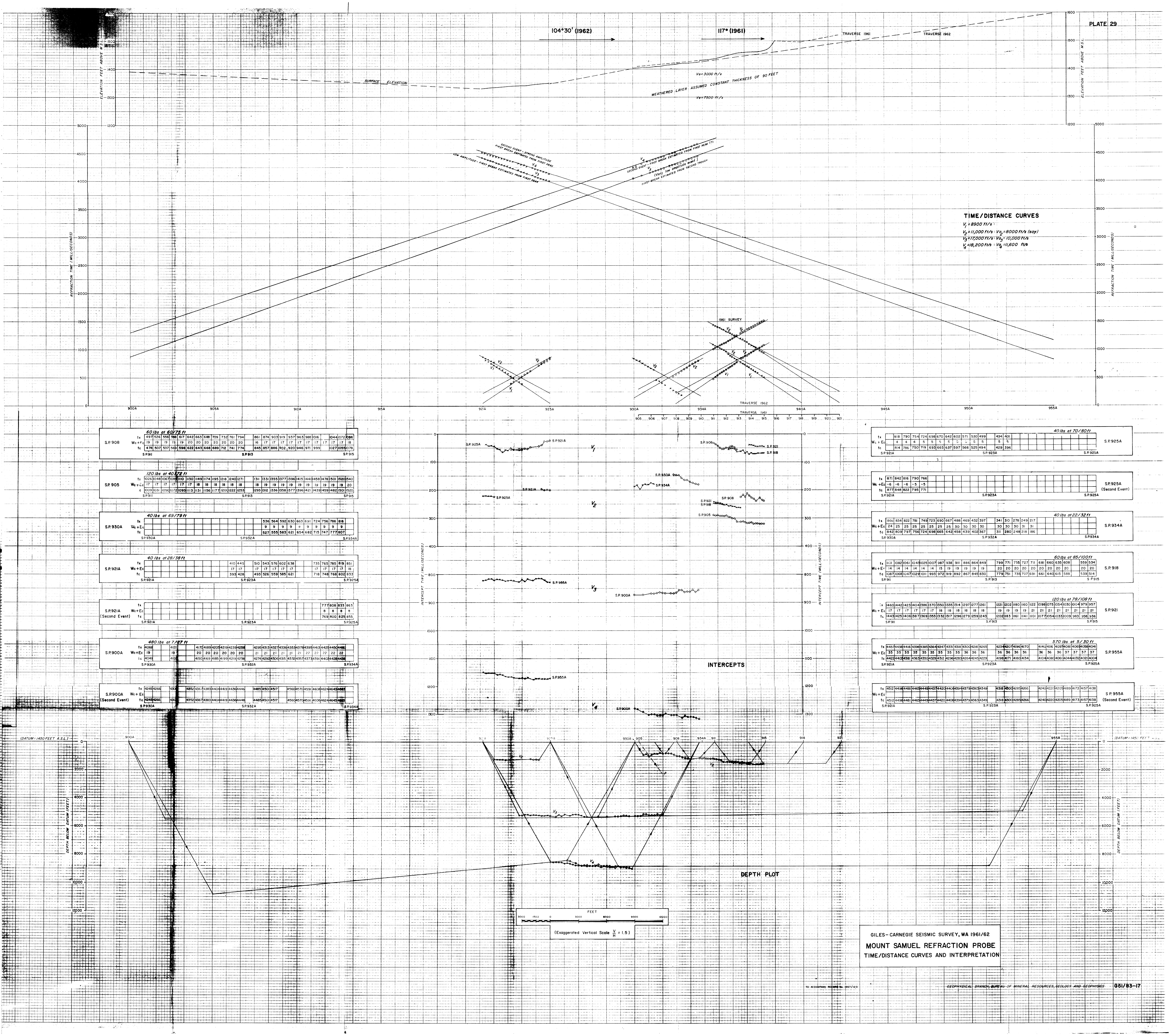


PLATE 29
104°30' (1962)
117° (1961)
TRAVERSE 1961
TRAVERSE 1962
SURFACE ELEVATION
Vo=3000 ft/s
WEATHERED LAYER ASSUMED CONSTANT THICKNESS OF 90 FEET
Vo=7500 ft/s
ELEVATION FEET ABOVE M.S.L.
REFRACTION TIME (MILLISECONDS)
SECOND EVENT - STRONG AMPLITUDE
FIRST BREAK ESTIMATED FROM FIRST PEAK
LOW AMPLITUDE - FIRST BREAK ESTIMATED FROM FIRST PEAK
SECOND EVENT - FIRST BREAK ESTIMATED FROM FIRST PEAK (?)
FIRST BREAK ESTIMATED FROM SECOND TROUGH
TIME/DISTANCE CURVES
$V_1$ = 8900 ft/s :
$V_2$ = 11,000 ft/s : $Va_2$ = 8000 ft/s (say)
$V_3$ = 17,000 ft/s : $Va_3$ = 10,000 ft/s
$V_4$ = 18,200 ft/s : $Va_4$ = 11,600 ft/s
1961 SURVEY
TRAVERSE 1962
TRAVERSE 1961
INTERCEPTS
INTERCEPT TIME (MILLISECONDS)
DEPTH PLOT
(DATUM: 1450 FEET A.S.L.)
DEPTH BELOW DATUM (FEET)
FEET
(Exaggerated Vertical Scale V/H = 1.5)
GILES-CARNEGIE SEISMIC SURVEY, WA 1961/62
MOUNT SAMUEL REFRACTION PROBE
TIME/DISTANCE CURVES AND INTERPRETATION
TO ACCOMPANY RECORD No. 1967/123
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
G51/B3-17

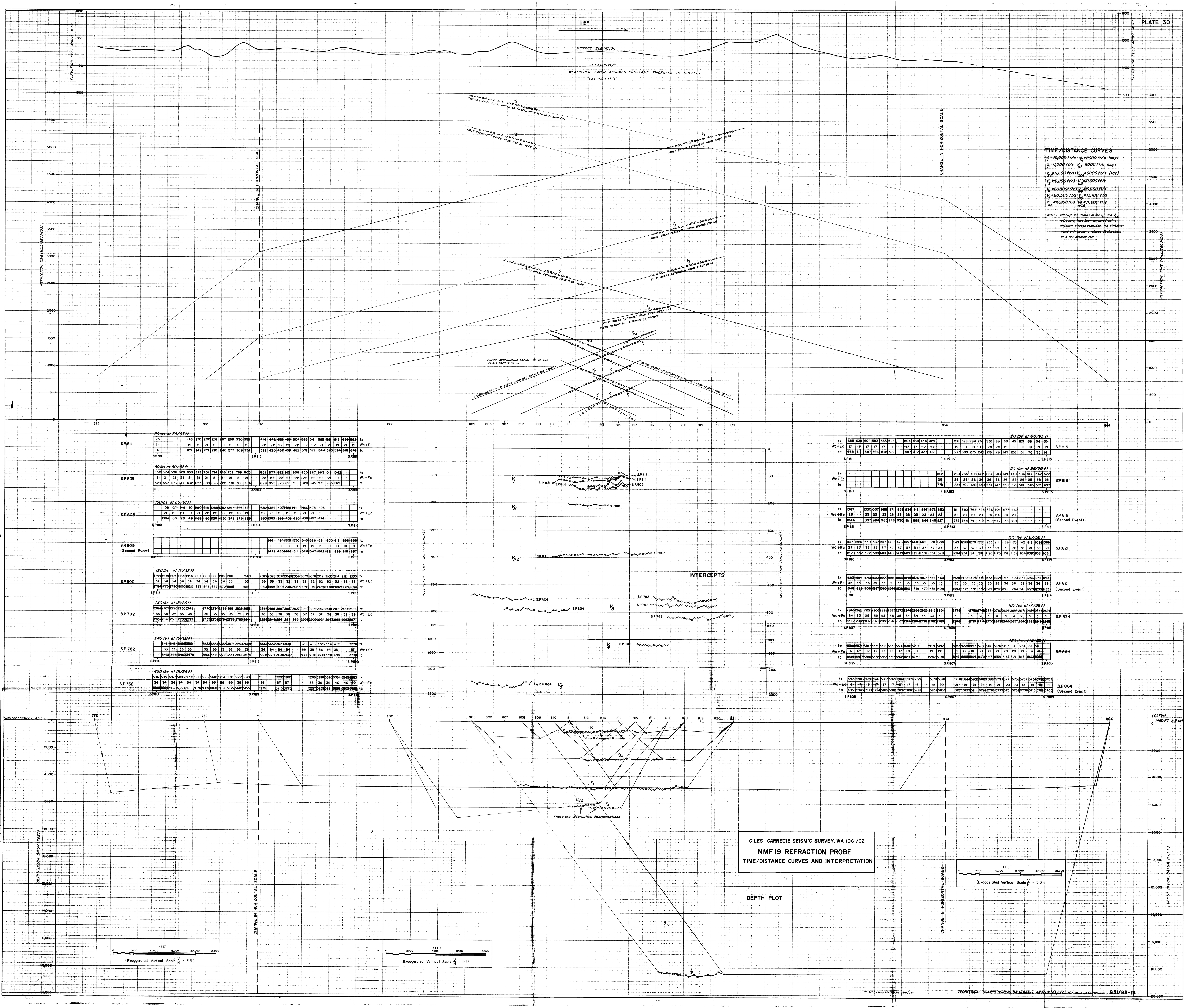


PLATE 30
116°
SURFACE ELEVATION
V0 = 3,000 ft/s
WEATHERED LAYER ASSUMED CONSTANT THICKNESS OF 100 FEET
Vd = 7,500 ft/s
ELEVATION FEET ABOVE M.S.L.
REFRACTION TIME (MILLISECONDS)
CHANGE IN HORIZONTAL SCALE
TIME/DISTANCE CURVES
NOTE: Although the depths of the V4 and V4A refractors have been computed using different average velocities, the difference would only cause a relative displacement of a few hundred feet.
FIRST BREAK ESTIMATED FROM SECOND TROUGH
FIRST BREAK ESTIMATED FROM FIRST PEAK
SECOND EVENT - FIRST BREAK ESTIMATED FROM SECOND TROUGH (?)
ENERGY ATTENUATING RAPIDLY ON V2 AND FAIRLY RAPIDLY ON V1
INTERCEPTS
INTERCEPT TIME (MILLISECONDS)
S.P. 811
S.P. 808
S.P. 805
S.P. 805 (Second Event)
S.P. 800
S.P. 792
S.P. 782
S.P. 762
S.P. 815
S.P. 818
S.P. 818 (Second Event)
S.P. 821
S.P. 821 (Second Event)
S.P. 834
S.P. 864
S.P. 864 (Second Event)
DEPTH BELOW DATUM (FEET)
(DATUM = 1450 FT A.S.L.)
These are alternative interpretations
DEPTH PLOT
(Exaggerated Vertical Scale V/H = 3.3)
(Exaggerated Vertical Scale V/H = 1.1)
GILES-CARNEGIE SEISMIC SURVEY, WA 1961/62
NMF 19 REFRACTION PROBE
TIME/DISTANCE CURVES AND INTERPRETATION
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS G51/B3-19

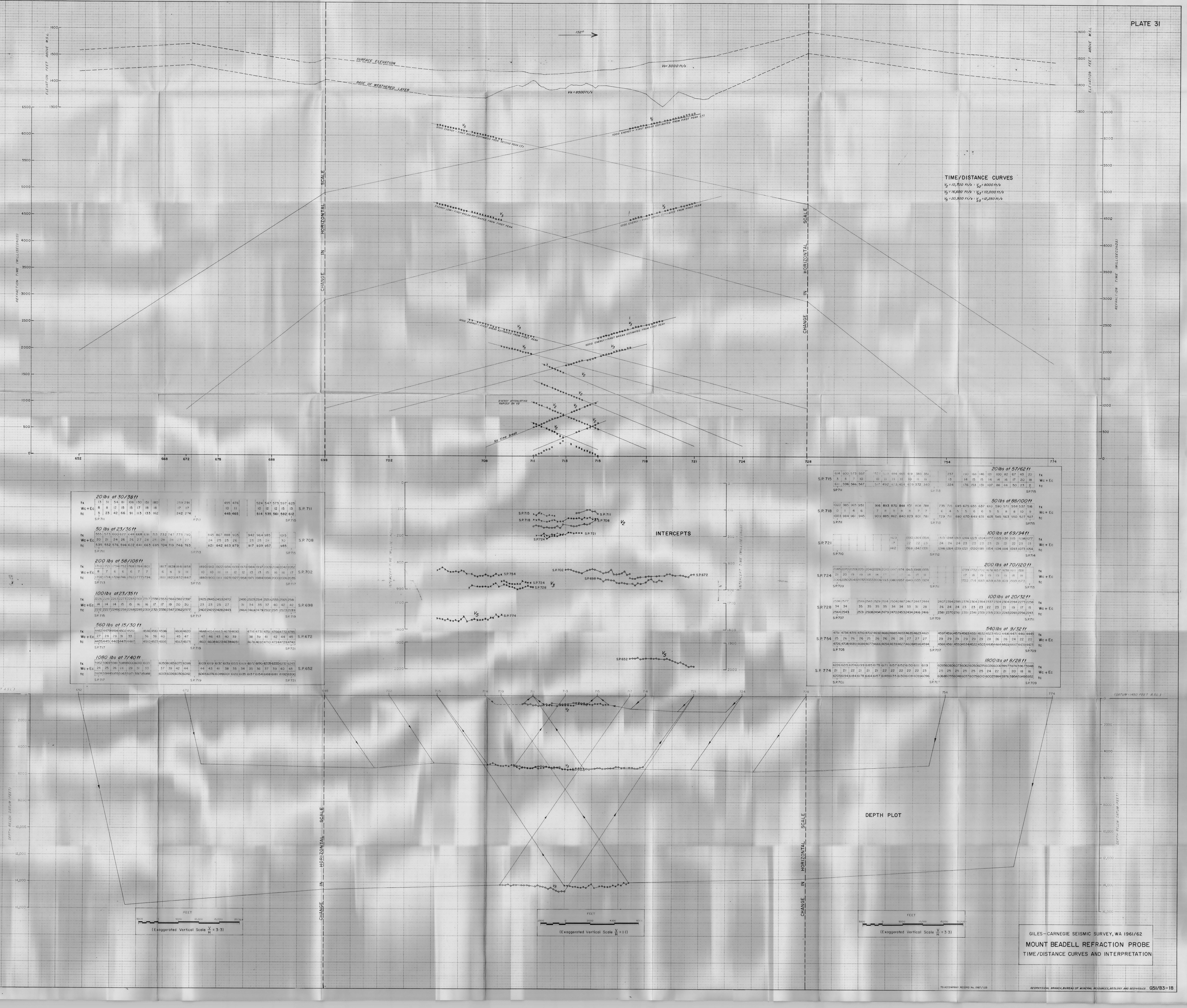
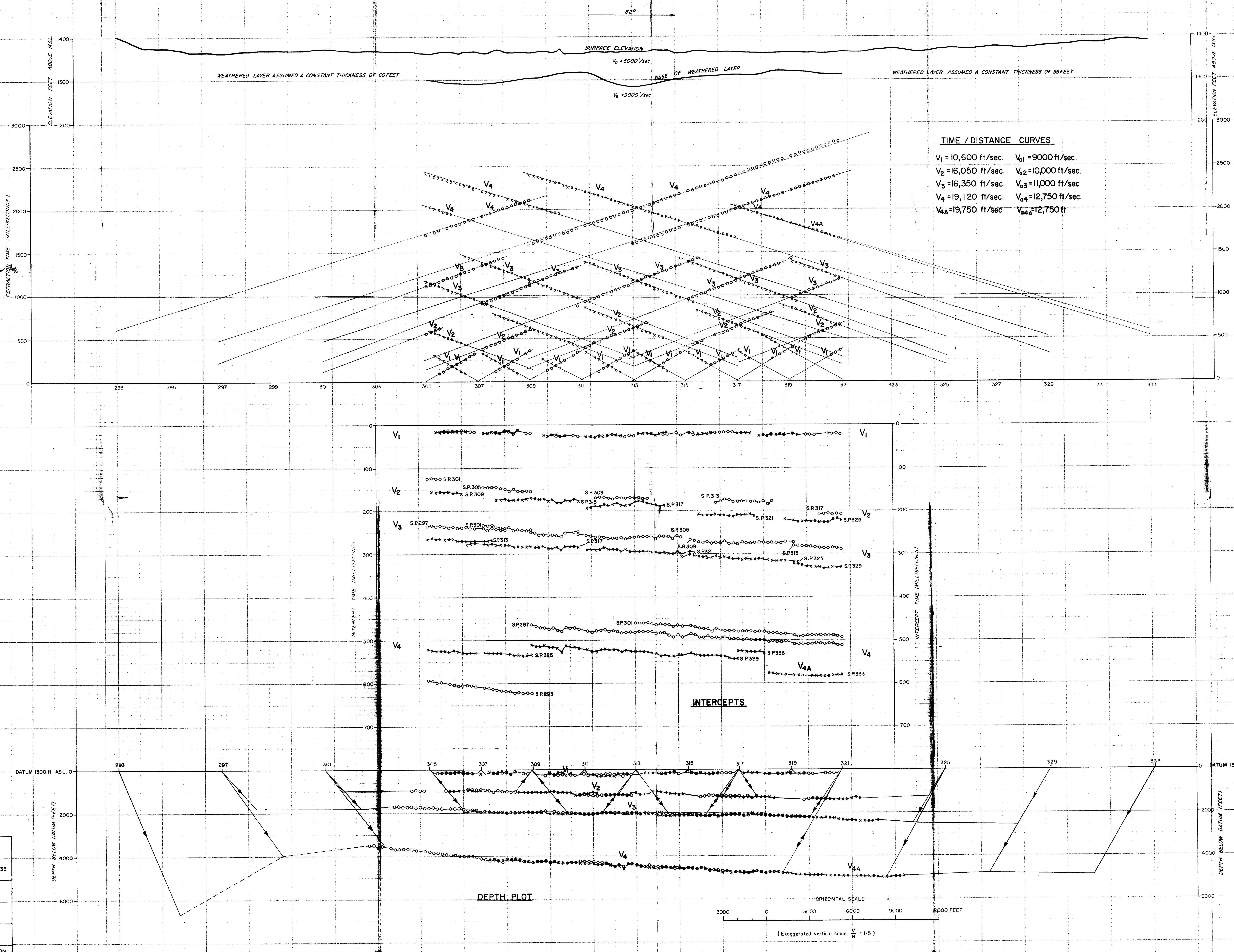


PLATE 31
SURFACE ELEVATION
BASE OF WEATHERED LAYER
ELEVATION FEET ABOVE M.S.L.
REFRACTION TIME (MILLISECONDS)
TIME/DISTANCE CURVES
CHANGE IN HORIZONTAL SCALE
INTERCEPTS
20 lbs at 30/39 ft
50 lbs at 23/36 ft
200 lbs at 58/108 ft
100 lbs at 23/35 ft
560 lbs at 15/30 ft
1080 lbs at 7/40 ft
20 lbs at 57/62 ft
50 lbs at 88/100 ft
100 lbs at 69/94 ft
200 lbs at 70/120 ft
100 lbs at 20/32 ft
540 lbs at 9/32 ft
1800 lbs at 8/28 ft
DEPTH PLOT
DEPTH BELOW DATUM (FEET)
FEET
(Exaggerated Vertical Scale V/H = 3·3)
(Exaggerated Vertical Scale V/H = 1·1)
GILES–CARNEGIE SEISMIC SURVEY, WA 1961/62
MOUNT BEADELL REFRACTION PROBE
TIME/DISTANCE CURVES AND INTERPRETATION
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
G51/B3-18




SHOTS WERE OFFSET FROM SHOT-POINTS AS FOLLOWS :—

| SHOT-POINT | 293 | 297 | 301 | 305 | 307 | 309 | 311 | 313 | 315 | 317 | 319 | 321 | 325 | 329 | 333 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPREAD 1 S.P. 305 – S.P. 309 | 300' E | 150' E | 150' E | ON PEG | ON PEG | 50' N | | 150' E | | 300' E | | 300' E | 150' E | | |
| SPREAD 2 S.P. 309 – S.P. 313 | | ON PEG | ON PEG | 150' E | | 50' S | ON PEG | 50' S | | 150' E | | 150' E | 300' E | 150' E | |
| SPREAD 3 S.P. 313 – S.P. 317 | | 150' W | 150' W | 150' W | | 150' W | | 50' N | ON PEG | 50' S | | 150' W | ON PEG | ON PEG | |
| **SPREAD 4 S.P. 317 – S.P. 321** | | 300' W | 300' W | 300' W | | 300' W | | 150' W | | 50' S | ON PEG | ON PEG | 150' W | 150' W | ON PEG |

# LAKE KEENE REFRACTION PROBE

## TIME / DISTANCE CURVES AND INTERPRETATION

TO ACCOMPANY RECORD No. 1967/123

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

G52/B3-28