1967/90
Copy 3

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PLATES TO ACCOMPANY

RECORD No. 1967/90

503256

BMR CANBERRA, A.C.T. Copy 3

SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QUEENSLAND 1963 - 1964

by

P. JONES and C.S. ROBERTSON

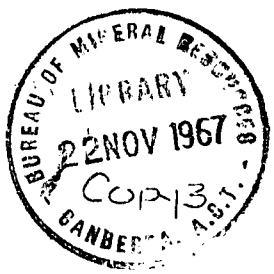
The information contained in this report has been obtained by the Department of National Development as part of the policy of the Commonwealth Governmment to assist in the exploration and development of mineral resources. It may not be published in any form or used in a company prospectus or statement without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1967/90



503256

SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QUEENSLAND 1963 - 1964

by

P. JONES and C.S. ROBERTSON

The information contained in this report has been obtained by the Department of National Development as part of the policy of the Commonwealth Governmment to assist in the exploration and development of mineral resources. It may not be published in any form or used in a company prospectus or statement without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.

RECORD No. 1967/90

SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QUEENSLAND 1963 - 1964

by

P. JONES and C.S. ROBERTSON

The information contained in this report has been obtained by the Department of National Development as part of the policy of the Commonwealth Government to assist in the exploration and development of mineral resources. It may not be published in any form or use in a company prospectus or statement without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.

CONTENTS

		Page
	SUMMARY	
1.	INTRODUCTION	1
2.	GEOLOGY	1
3.	PREVIOUS GEOPHYSICAL WORK	8
4.	OBJECTIVES OF SURVEY AND PROGRAMMES	14
5.	RESULTS AND INTERPRETATION	20
6.	CONCLUSIONS AND RECOMMENDATIONS	61
7.	REFERENCES	63
APPENDIX A.	Staff and equipment	65
APPENDIX B.	Table of operations	68
APPENDIX C.	Shot-hole drilling statistics	72
APPENDIX D.	Effect of a dipping prism on a reflection from a horizontal plane below it	74

Note: This Record supersedes Records Nos. 1965/39 and 1965/75

1967/90

ILLUSTRATIONS

		Drawing Number
Plate 1.	Geology and locality map	E53/B3-1
Plate 2.	Layout of traverses	F54/B3-23
Plate 3.	Bouguer anomaly contours and layout of seismic traverses	F54/B3-23-1
Plate 4.	Bouguer anomalies and gravity units	F54/B3-48
Plate 5.	Summary of refraction depth-probe results on Traverses A, B, C, D, V_1, and V_2	F54/B3-47-1
Plate 6.	Corrected refraction time/distance graph for Traverse A	F54/B3-43-1
Plate 7.	Corrected refraction time/distance graph for Traverse B	F54/B3-44-1
Plate 8.	Corrected refraction time/distance graph for Traverse C	F54/B3-45-1
Plate 9.	Corrected refraction time/distance graph for Traverse D	F54/B3-46-1
Plate 10.	Mean corrected time/distance graph for Traverse D, constant velocity layer removed	F54/B3-110
Plate 11.	Corrected refraction time/distance graph for Traverse V_1	F54/B3-108
Plate 12.	Corrected refraction time/distance graph for Traverse V_2	F54/B3-109
Plate 13.	Comparison of corrected refraction time/distance graphs for Traverses A, B, C, D, V_1, and V_2	F54/B3-107
Plate 14.	Variable-area cross-section for reflection Traverse D	F54/B3-154
Plate 15.	Variable-area cross-section for reflection Traverse V, centre 12 traces	F54/B3-58
Plate 16.	Variable-area cross-section for reflection Traverse V, even number shot-points, 24 traces	F54/B3-57
Plate 17.	Variable-area cross-section for reflection Traverse V, two-fold stack	F54/B3-59
Plate 18.	Variable-area cross-section for reflection Traverse B, centre 12 traces	F54/B3-90

Plate 19.	Variable-area cross-section for reflection Traverse B, whole number shot-points, 24 traces	F54/B3-89
Plate 20.	Variable-area cross-section for reflection Traverse E, two-fold stack	F54/B3-91
Plate 21.	Variable-area cross-section for reflection Traverse S, centre 12 traces	F54/B3-87
Plate 22.	Variable-area cross-section for reflection Traverse S, even number shot-points, 24 traces	F54/B3-86
Plate 23.	Variable-area cross-section for reflection Traverse S, two-fold stack	F54/B3-88
Plate 24.	Variable-area cross-section for reflection Traverse A, SP 1002 to SP 1012	F54/B3-153
Plate 25.	Variable-area cross-section for reflection Traverse A, SP 954 to SP 1001	F54/B3-92
Plate 26.	Variable-area cross-section for reflection Traverse A, SP 855 to SP 953, centre 12 traces	F54/B3-94
Plate 27.	Variable-area cross-section for reflection Traverse A, SP 856 to SP 952, even number shot-points, 24 traces	F54/B3-93
Plate 28.	Variable-area cross-section for reflection Traverse A, SP 856 to SP 952, two-fold stack	F54/B3-95
Plate 29.	Variable-area cross-section for reflection Traverse Q	F54/B3-141
Plate 30.	Variable-area cross-section for reflection Traverse N	F54/B3-105
Plate 31.	Variable-area cross-section for reflection Traverse R	F54/B3-104
Plate 32.	Corrected refraction time/distance graph for Traverse N	F54/B3-166
Plate 33.	Refraction profile for Traverse O, SP 6479 to SP 6501	F54/B3-168
Plate 34.	Refraction profile for Traverse O, SP 6444 to SP 6466	F54/B3-167
Plate 35.	Corrected refraction time/distance graph for Traverse R	F54/B3-120
Plate 36.	Variable-area noise test profile, SP 7783, Traverse V	F54/B3-165

Plate 37.	Variable-area noise test profile, SP 7676, Traverse V	F54/B3-164
Plate 38.	Variable-area noise test profile, SP 1007, Traverse A	F54/B3-160
Plate 39.	Variable-area noise test profile, SP 927, Traverse A	F54/B3-163
Plate 40.	Variable-area noise test profile, SP 6718, Traverse R	F54/B3-161
Plate 41.	Variable-area noise test profile, SP 6105, Traverse N	F54/B3-162
Plate 42.	Variable-area noise test profile, SP 206, Traverse F	F54/B3-157
Plate 43.	Variable-area noise test profile, SP 189, Traverse F	F54/B3-159
Plate 44.	Variable-area noise test profile, SP 178, Traverse F	F54/B3-158
Plate 45.	Graphs of frequency against wave number for noise events recorded on all noise tests	F54/B3-170
Plate 46.	Corrected refraction time/distance graphs for Traverses P, J, I, and K	F54/B3-133
Plate 47.	Variable-area cross-section for reflection Traverse F, SP 161 to SP 251, 1800-ft split spreads	F54/B3-136
Plate 48.	Variable-area cross-section for reflection Traverse F, SP 160-1/3 to SP 172, SP 175 to SP 180, and SP 241 to SP 248, 600-ft split spreads	F54/B3-138
Plate 49.	Variable-area cross-section for collinear offset shots, Traverse F, SP 181 to SP 184	F54/B3-145
Plate 50.	Variable-area cross-section for collinear offset shots, Traverse F, SP 176 to SP 178	F54/B3-144
Plate 51.	Variable-area cross-section for multiple coverage reflection Traverse F, shot-points MC 22 to MC 85, three-fold stack, nearest 12 traces	F54/B3-84
Plate 52.	Variable-area cross-section for multiple coverage reflection Traverse F, shot-points MC 112 to MC 251, three-fold stack, nearest 12 traces	F54/B3-96
Plate 53.	Variable-area cross-section for multiple coverage reflection Traverse F, shot-points MC 21 to MC 80, three-fold stack, 24 traces	F54/B3-81

Plate 54.	Variable-area cross-section for multiple coverage reflection Traverse F, shot-points MC 116 to MC 255, three-fold stack, 24 traces	F54/B3-98
Plate 55.	Variable-area cross-section for multiple coverage reflection Traverse F, shot-points MC 23 to MC 87, six-fold stack, nearest 12 traces	F54/B3-85
Plate 56.	Variable-area cross-section for multiple coverage reflection Traverse F, shot-points MC 113 to MC 252, six-fold stack, nearest 12 traces	F54/B3-97
Plate 57.	Variable-area cross-section for multiple coverage reflection Traverse F, shot-points MC 24 to MC 79, six-fold stack, 24 traces	F54/B3-82
Plate 58.	Variable-area cross-section for multiple coverage reflection Traverse F, shot-points MC 119 to MC 254, six-fold stack, 24 traces	F54/B3-99
Plate 59.	Variable-area cross-section for multiple coverage reflection Traverse F, shot-points MC 24 to MC 79, twelve-fold stack, 24 traces	F54/B3-83
Plate 60.	Variable-area cross-section for multiple coverage reflection Traverse F, shot-points MC 119 to MC 254, twelve-fold stack, 24 traces	F54/B3-100
Plate 61.	Corrected refraction time/distance graphs for Traverse F, SP 236 to SP 248	F54/B3-151
Plate 62.	Uncorrected refraction time/distance graphs for Traverse F, SP 171 to SP 178	F54/B3-132
Plate 63.	Variable-area cross-section for velocity profile on Traverse E	F54/B3-156
Plate 64.	Variable-area cross-section for velocity profile on Traverse U	F54/B3-102
Plate 65.	Variable-area cross-section for velocity profile on Traverse W	F54/B3-106
Plate 66.	Variable-area cross-section for velocity profile on Traverse T	F54/B3-103
Plate 67.	Variable-area cross-section for velocity profile on Traverse H	F54/B3-155
Plate 68.	$T^2 : X^2$ graph for velocity profile on Traverse E	F54/B3-113
Plate 69.	$T^2 : X^2$ graph for velocity profile on Traverse U	F54/B3-116

Plate 70.	T^2 : X^2 graph for velocity profile on Traverse W	F54/B3-117
Plate 71.	T^2 : X^2 graph for velocity profile on Traverse T	F54/B3-115
Plate 72.	T^2 : X^2 graph for velocity profile on Traverse H	F54/B3-114
Plate 73.	Graph of average vertical velocities for the Toko Syncline area	F54/B3-131
Plate 74.	Average t : Δt curves for the Toko Syncline area	F54/B3-130
Plate 75.	Graph of reflection time against depth for the Toko Syncline area	F54/B3-173
Plate 76.	Graph of interval velocity against depth for the Toko Syncline area	F54/B3-174
Plate 77.	Variable-area cross-section for reflection Traverse M	F54/B3-139
Plate 78.	Variable-area cross-section for reflection Traverse L	F54/B3-142
Plate 79.	Variable-area cross-section for reflection Traverse E	F54/B3-143
Plate 80.	Variable-area cross-section for reflection Traverse G	F54/B3-140
Plate 81.	Variable-area refraction profiles, Traverse E	F54/B3-101
Plate 82.	Corrected refraction time/distance graph for Traverse E	F54/B3-150
Plate 83.	Comparison of seismic and gravity results on Traverse F	F54/B2-31-1
Plate 84.	Interpretation of results near the south-western margin of the Toko Syncline	F54/B3-172

SUMMARY

During 1963 and 1964 the Bureau of Mineral Resources carried out a total of 12 crew months of reconnaissance and experimental seismic work in the Boulia - Bedourie area of the south-eastern Georgina Basin in western Queensland. In the area south-east of the Toko Range good results were obtained and it was shown that the Toko Syncline extends south-eastwards under Mesozoic sediments, alluvial cover, and sand at least as far as the Sandringham - Lake Wickamunna area. In the area east of Pulchera Waterhole, the Toko Syncline was shown to contain up to about 15,000 ft of Palaeozoic and Mesozoic sediments and there was evidence of a considerable thickness of Proterozoic sediments beneath these. The cross-sectional shape of the Toko Syncline was defined, except for its western margin where results were poor and structure complex.

Between the Toko Syncline and Canary No. 1 Bore to the north-east it was shown fairly conclusively that there are no deep troughs of Palaeozoic sediments comparable to the Toko Syncline. Where Palaeozoic sediments are present beneath the Mesozoic in this region their thickness is probably small. Deep reflections suggest that much of the area is underlain by a considerable thickness of Proterozoic sediments and there are indications that there may be intrusions of igneous rocks in some areas of low Bouguer gravity anomaly. Elsewhere to the north-east of the Toko Syncline the seismic results show no obvious correlation with gravity anomalies.

1. INTRODUCTION

During the winter months of both 1963 and 1964 the Bureau of Mineral Resources (BMR) carried out programmes of reconnaissance and experimental seismic work in the south-eastern part of the Georgina Basin in Queensland near the Northern Territory border. The survey area is remote and generally arid. The country varies from flat clay pans and gently undulating gibber country to the red sand ridge country of the Simpson Desert in the vicinity of the Mulligan River and west of it.

Commencing on 26th April 1963 the BMR Seismic Party No. 1 did four weeks of reconnaissance reflection and refraction seismic work between Marion Downs Homestead and the stratigraphic hole drilled by Phillips Petroleum Company near Canary Homestead (Canary No. 1 Bore), 37 miles south-east of Boulia (Plates 1 to 3). On 23rd May 1963 the party moved to an area about 50 miles north-west of Bedourie, where they spent the rest of the survey time available in 1963 (up to 27th September) investigating by seismic means an extension of the Toko Syncline into this area.

In 1964 the party commenced work in the survey area on 1st April and carried out eight weeks of reconnaissance reflection and refraction work between Herbert Downs and Marion Downs Homesteads. On 21st May the party moved from near Herbert Downs to an area 20 miles east of Marion Downs. The following 15 weeks were spent investigating the sedimentary section between Hilary Dam, 20 miles south-west of Marion Downs, and Canary No. 1 Bore. On 3rd September the party moved to the area 50 miles north-west of Bedourie and spent the remainder of the survey time (up to 26th October) doing experimental seismic work in the Toko Syncline. Plates 2 and 3 show the locations of the seismic traverses in relation to the main topographic and Bouguer anomaly features.

Details of staff and equipment used for the surveys are given in Appendix A and a number of statistics relating to the operation of the seismic party are included in Appendices B and C.

2. GEOLOGY

The term 'Georgina Basin' was originally applied to the drainage basin of the Georgina River but it has later been used in a geological context and applied variously be different authors. For the purpose of this report the Georgina Basin is defined as that area containing several thousand feet of marine calcareous and sandy Palaeozoic sediments in north-western Queensland and central-eastern Northern Territory. The Palaeozoic basin is bounded in the east and north-east by the Precambrian of the Cloncurry/Mount Isa massif. In the south and south-west it is bounded by the Proterozoic Arunta Complex and partly covered by the Mesozoic of the Great Artesian Basin. The Lower Proterozoic rocks in the Davenport and Warramunga Geosynclines form the western boundary. A sub-surface ridge of granite, the Lucknow Granite, may either constitute the south-eastern boundary of the Georgina Basin or it may form a divide separating the Georgina Basin from a possible basin containing Palaeozoic sediments beneath the Great Artesian Basin east of the ridge.

The Georgina Basin is an elongated depression running north-west to south-east in the Precambrian basement; it is filled with Palaeozoic sediments ranging in age mainly from lower Middle Cambrian to Ordovician. These unconformably overlie Upper Proterozoic (and Lower Cambrian in the southern part of the area), Lower Proterozoic, and Archaean rocks. Marked facies changes take place within the Middle Cambrian - Ordovician sequence; predominantly clastic older deposits crop out at the basin edges and are overlain and laterally replaced by predominantly carbonate sediments in the more central parts. Three major rock stratigraphic units have been defined (Mulder, 1961):

Group	Age
Undilla Group	Lower Middle Cambrian to Upper Cambrian
Ninmaroo Group	Upper Cambrian to Lower Ordovician
Toko Group	Lower Ordovician to Middle Ordovician

Tectonic movements in the basin during and after the deposition of sediments are characterised by a strong WNW trend. Epeirogenic movements beginning in the Middle Cambrian resulted in the formation of the Dulcie, Tarlton, and Toko Synclines along the southern edge of the basin. These replace each other en echelon and their axes follow this dominant trend. Tectonic deformation decreases rapidly away from the southern margins of the basin and the northern and mid-basin beds are mostly near-horizontal. Sedimentation in the basin was terminated by orogenic movements which began in post-Middle Ordovician times and which reached a climax after the Upper Devonian. Triassic and Lower Cretaceous rocks present in the area have also suffered minor folding and faulting. The structures in these rocks are generally reflections of displacements of the underlying Palaeozoic and older rocks along the main structural trends.

The geology of the Mount Whelan and Springvale 1:250,000 map areas, which is of particular importance to this report, is described in detail by Reynolds (1960, 1964). A stratigraphic table for these areas is shown in Table 1 (after Reynolds, 1964).

In this region the most extensive development of Cambrian and Ordovician sedimentation is in the Toko Syncline and some of the best exposures can be seen in the Toko Range - Mount Whelan area. The Toko Syncline is a regional asymmetric syncline measuring about 40 miles in width and trending approximately south-east to south-south-east.

TABLE 1

Stratigraphic Table - Mount Whelan and Springvale 1:250,000 map areas

Age	Formation	Thickness (ft)	Lithology
TERTIARY	Austral Downs Limestone	less than 10 in outcrop	Limestone and chalcedony
	Mount Coley Sinter	170	Chalcedony and siliceous sinter over fine-grained sandstone
	-		Laleritisation and deep weathering
	Marion Formation	55	Quartz sandstone, quartz, chert, grit, sandy siltstone
	DISCONFORMITY		
CRETACEOUS	Wilgunya Formation:		
	Upper beds	500 - 1000	Grey mudstone (lateritised in outcrop), fossiliferous calcareous siltstone
	Toolebuc Member	up to 10	Fossiliferous pink platy limestone with green shale interbeds, ferrugineous in part
	Lower beds	450 - 550	Sandy, glauconitic, gypsiferous grey mudstone (lateritised in part) with calcareous concretions
	Longsight Sandstone	550 in bores	Poorly sorted silty sandstone, conglomerate and silicifed brown sandstone, glauconitic in part, shale and lignite in bores
	DISCONFORMITY		
LOWER JURASSIC?		380 +	Red claystone, partly calcareous, minor sandstone (found only in bores)
	UNCONFORMITY		
PERMIAN?		Unknown	Unconsolidated fluvio-glacial(?) boulders, cobbles, and pebbles of silicified sandstone mainly
	UNCONFORMITY		

Age			Formation	Thickness (ft)	Lithology
UPPER SILURIAN TO LOWER DEVONIAN			Cravens Peak Beds	456 +	Brown ferruginised fine to medium-grained quartz sandstone with clay pellets and basal conglomerate in parts
			DISCONFORMITY		
ORDOVICIAN	MIDDLE ORD.	Toko Group	Mithaka Formation	200 - 400	Brown gypsiferous siltstone and sandstone, minor pellet beds
			Carlo Sandstone	200 +	Red, brown thick-bedded sandstone, clay pellet beds and some siltstones; cross-bedded
			Nora Formation	165 - ?500	Green, brown, purple gypsiferous siltstone and brown sandstone; calcarenite and coquinite beds, clay pellets common
	LOWER ORD.		Coolibah Formation	50 - 520	Grey calcilutite, some oolitic, green white, chert lenses, minor calcarenite, dolarenite
			Kelly Creek Formation	250	Lower part mainly sandstone and some siltstone overlain by dolomite with marl and chert, laminated to thin bedded
			DISCONFORMITY?		
CAMBRIAN TO ORDOVICIAN			Ninmaroo Formation	up to 2400 +	Calcilutite, calcarenite and dolarenite, sandy in part, sandstone and siltstone interbeds, algae, intraformational breccia, oolitic limestone
			DISCONFORMITY		
CAMBRIAN	UPPER		Georgina Limestone	100 in outcrop, probably more than 1100 in Tysons Bore	Thinly bedded hard grey and soft white calcilutite, some sandy, with chert, calcareous sandstone, oolitic limestone, breccia, two coloured blue grey and brown limestone
	MIDDLE		Undifferentiated	Not known but probably thin	Laminated calcilutite, some sandy and minor calcareous sandstone
			UNCONFORMITY?		

Age	Formation	Thickness (ft)	Lithology
LOWER CAMBRIAN	Sylvester Sandstone	1200	Silicified dense brown sandstone and green siltstone
	Sun Hill Arkose	150 +	Arkose, arkosic sandstone, conglomerate, siltstone, dolomite, greywacke
	UNCONFORMITY?		
UPPER PROTEROZOIC	Field River Beds	1000 +	Interbedded green siltstone and boulder beds, some tillitic texture; arkose, dolomite, siltstone and sandstone
	UNCONFORMITY?		
ARCHAEAN		Unknown	Granite, schist, pegmatite

On the north-eastern limb of the Toko Syncline in the Mount Whelan 1:250,000 map area, the exposed sediments dip relatively gently to the south-west whereas on the south-western limb the dip of the beds is much steeper. The steeper dips are probably associated with major faulting along the south-western margin of the syncline.

Seismic work carried out across the Toko Syncline by the French Petroleum Company (Aust) Pty Ltd (1965) in the Bedourie region indicated that the sedimentary section was about 20,000 ft thick in the southern part of the syncline (see Chapter 3). During and immediately after this seismic survey the French Petroleum Company drilled three stratigraphic bores. Bedourie F.P.C.(A) Scout Hole No. 1 was drilled to a depth of 1004 ft about 9 miles south-east of Sandringham Homestead (Plate 2). This bore encountered the Transition beds, which separate the Lower Cretaceous from the Upper Jurassic sediments at 526 ft, and the unconformity at the base of the Mesozoic at 780 ft. Ordovician Mithaka Formation was penetrated below the unconformity. Marduroo No. 1 Bore was drilled to a depth of 3854 ft above half way between Bedourie and Coorabulka. This bore encountered the Transition beds at a depth of 920 ft and was drilled through the Mooga sandstone from 994 to 1242 ft and through the Proterozoic Field River Beds from 1242 to 3854 ft. The Brothers No. 1 Bore was located about 10 miles north-west of Bedourie and was drilled to a total depth of 4147 ft. In this bore the Transition beds were found at a depth of 882 ft and Mooga sandstone was then penetrated to a depth of 1153 ft, after which Upper to Middle Cambrian limestones were penetrated down to the total depth of 4147 ft.

Upper Proterozoic sediments crop out to the south-east of Glenormiston in the Sun Hill area and also near the headwaters of Sylvester Creek. To the south-west, in the Field River area, Upper Proterozoic sediments have been recognised with a possible thickness

greater than 7000 ft. Upper Proterozoic sediments have also been penetrated (Phillips Petroleum Company, 1963) in stratigraphic holes near Canary and Black Mountain (Plate 1).

An apparently conformable sequence of Upper Cambrian and Lower and Middle Ordovician carbonate and sandstone sediments is exposed on the north-eastern limb of the Toko Syncline. This sequence is divided into the Upper Cambrian/Middle Ordovician Ninmaroo Formation and the Middle Ordovician Toko Group (Mulder, 1961). Middle Cambrian sediments crop out to the north-east of the Toko Syncline and may also occur in the syncline beneath the Ninmaroo Formation. The Cambro-Ordovician sediments extend in outcrop as far east as Herbert Downs in the north of the Mount Whelan 1:250,000 map area, but elsewhere Palaeozoic and older rocks are covered by the Mesozoic sediments of the Great Artesian Basin. The latter obscure the eastern limit of Palaeozoic sedimentation.

The Cambrian and Ordovician marine sediments have yielded hydrocarbons and are generally regarded as adequate source beds for oil or gas. Flammable gas was encountered in Cambrian rocks in a water well at Ammaroo Homestead, 240 miles west-north-west of the survey area, but no oil seeps have been recorded.

Post-Ordovician and pre-Mesozoic sediments are practically unknown in outcrop in the south-eastern Georgina Basin. However, P. J. Jones (Reynolds & Pritchard, 1964, Appendix 4) reports the occurrence of coelolepod fish scales of Upper Silurian/Lower Devonian age in samples from shot-holes in the Toko Range to the north-west of the survey area. Table 2 is a stratigraphic table of formations encountered in the Papuan Apinaipi Petroleum Co. Ltd Netting Fence No. 1 well, which was drilled on the Netting Fence Anticline, a small structure within the Toko Syncline near the north-west corner of the Mount Whelan 1:250,000 map area (Plate 1).

TABLE 2

Stratigraphic table - Netting Fence No. 1 well

Age	Formation		Thickness (ft)
ORDOVICIAN	Toko Group	Carlo Sandstone	410+
		Nora Formation	373
		Coolibah Formation	117
		Kelly Creek Formation	361
CAMBRO-ORDOVICIAN	Ninmaroo Formation		1120
UPPER CAMBRIAN	Georgina Limestone		1709

Age	Formation	Thickness (ft)
MIDDLE TO UPPER CAMBRIAN	Mungerebar Limestone	265
MIDDLE CAMBRIAN	Steamboat Sandstone 'Netting Fence' Thorntonia Limestone	725 1348 162
PRECAMBRIAN	Granite	76 +
		Total: 6666

The Mesozoic (probably mainly Upper Jurassic to Lower Cretaceous) sandstones and claystones unconformably overlie the Cambrian, Ordovician, and possibly other Palaeozoic marine sediments in the Mount Whelan area. They thicken towards the south-east, reaching a thickness of 1500 ft near Lake Wickamunna (Plate 2). Further to the east, results of Canary No. 1 Bore, drilled by Phillips Petroleum Co., indicated that the Mesozoic section rests on Upper Proterozoic sediments.

In this bore 500 ft of Lower Cretaceous Wilgunya Formation were penetrated before the drill encountered unfossiliferous sediments for which an Upper Proterozoic age was confirmed by radioactive dating using the rubidium - strontium method (J. Casey, pers. comm.). The bore bottomed in Proterozoic sandstone at a total depth of 3218 ft. To the south of Canary, near Coorabulka, the French Petroleum Company (Aust) Pty Ltd Marduroo No. 1 Bore penetrated 1242 ft of Cretaceous sediments before entering Upper Proterozoic Field River Beds. The Mesozoic rocks in this area form the main aquifer and the impermeable cap of the artesian sequence in the north-west of the Great Artesian Basin. About 80 ft of Tertiary sandstone and lacustrine limestone with chalcedony overlies the older rocks.

The occurrence of potential source rocks for petroleum in the Lower Palaeozoic carbonate sequence has already been mentioned. Pyrite and gypsum, which are evidence for a reducing environment during deposition, are common in the marine fossiliferous Cretaceous claystone. Siltstone, soft argillaceous limestone, dense limestone beds within the carbonate sequence, or the Cretaceous claystone could form cap rocks. Time-breaks occur within the carbonate sequence and, in places, within the siltstone of the Swift Formation. The Kelly Creek Formation overlies the carbonates disconformably. Hydrocarbons from the carbonates may thus have escaped before the siltstone cap was deposited. Apart from the Mesozoic sandstone, the only possible reservoirs are in the older carbonate rocks, particularly in the dolomitised zones where vugs are numerous, in intraformational breccias and in limestones that have become sheared and faulted. Basal sands may occur at depth near the basement ridges over and along which the Lower Palaeozoic seas transgressed.

3. PREVIOUS GEOPHYSICAL WORK

Gravity surveys

Reconnaissance gravity surveys were made in western Queensland by the Bureau of Mineral Resources in 1957 and 1958 (Neumann, 1959a & b) and a helicopter gravity survey was made in 1961 (Lonsdale, 1962). Mines Administration Pty Ltd in 1959 made a semi-detailed gravity survey in western Queensland, covering parts of the Georgina Basin, on behalf of Papuan Apinaipi Petroleum Company Ltd (1962). The results of these surveys, which cover much of the Georgina Basin and part of the Greater Artesian Basin, have been compiled in the form of Bouguer anomaly maps (Gibb, 1966; Barlow, 1966).

On the basis of the correlation of the geology and the Bouguer anomaly maps the area has been divided into three main zones. These are: the Cloncurry Fold Belt and its extension to the south and west below the younger sediments; the Georgina Basin; and part of the Great Artesian Basin. The Cloncurry Gravity High is the term used by Gibb to describe the gravity expression of the Cloncurry Fold Belt and its southern extension. This area is seen on the Bouguer anomaly map (Plate 4) as an area of north-north-west trending, elongated, steep sided, positive anomalies, separated in the south from the less pronounced north-east trending, negative anomalies of the Great Artesian Basin, by a fairly uniform gravity gradient called the Diamantina Gravity Gradient. The western boundary of the Cloncurry Gravity High is also expressed by a sharp gravity gradient between the positive anomalies of the 'high' and the negative anomalies of the Georgina Basin. This boundary is cut by a large south-east trending gravity 'low' (Gibb's Unit 23), the north-west end of which coincides with the exposed part of the Toko Syncline. The Cloncurry Gravity High has been further subdivided by Gibb into 22 Bouguer anomaly units. In the Boulia area, Starkey (Papuan Apinaipi Petroleum Co. Ltd, 1962) had previously described four distinct zones of gravity 'highs', which correlate with some of Gibb's units. These were, as shown in Plate 4:

(1) A zone of positive anomalies trending north-west through Glenormiston in the western part of the area (Unit 18).

(2) A zone extending from Dajarra, west of Boulia and to the east of Marion Downs (Unit 20, the Boulia Gravity Ridge).

(3) A zone extending from Chatsworth to Springvale (Units 3 and 4, the Burke River Structures).

(4) A zone through Middleton in the eastern part of the area (Unit 12).

Between these four gravity 'highs' there are the following gravity 'lows':

(a) The Glenormiston Gravity Low (Unit 19).

(b) The Kalkadoon Gravity Low (Unit 1).

(c) The Williams Gravity Low (Unit 9).

The present seismic surveys cover parts of the Toko Syncline gravity 'low', the Glenormiston Gravity Low, the Glenormiston gravity 'highs', and the Boulia Gravity Ridge.

The outstanding feature of the Bouguer anomaly map is that the anomalies associated with the surface features of the Toko Syncline and the Cloncurry Fold Belt in the north all extend southwards under the younger sediments. With the exception of the Toko Syncline, Gibb shows that these gravity anomalies of the Georgina Basin and Cloncurry Gravity High can all be interpreted as being caused by density changes within the Precambrian basement.

The Toko Syncline gravity 'low' may be explained by a density contrast between the less dense Palaeozoic sediments of the syncline and the underlying and adjacent basement rocks. The western edge of the Toko Syncline is bounded by a fault, the southern extension of the Toomba Range Fault. The steep gradient on the western edge of the Toko Syncline gravity 'low' indicates that this fault also extends south under the Mesozoic cover.

A depth estimate made using assumed density values for the Cambro-Ordovician sediments indicates that the maximum thickness of the Lower Palaeozoic sediments is of the order of 8000 ft near the Toko Range.

Aeromagnetic surveys

In 1958 the Bureau of Mineral Resources made an aeromagnetic reconnaissance survey (Jewell, 1960) consisting of a series of widely spaced traverses in the western part of the Great Artesian Basin and including the south-eastern part of the Georgina Basin. More detailed aeromagnetic surveying of the Georgina Basin and adjoining areas was carried out by the Bureau of Mineral Resources in 1963 and 1964 (Wells, Milsom, and Tipper, 1966).

The earlier reconnaissance aeromagnetic results showed good qualitative agreement with the known regional structures of the basin and the main gravity anomalies. In the north there is a zone of irregular magnetic anomalies suggesting shallow basement, in contrast to the smooth anomalies to the east and south over the deeper part of the Great Artesian Basin. The boundaries of this shallow basement area agree closely with those of the Cloncurry Gravity High. There is also good agreement within this area between a suggested north-south correlation of the positive magnetic anomalies and the gravity and surface trends.

The BMR aeromagnetic survey in 1964 showed that over the Mount Whelan 1:250,000 map area the magnetic pattern is dominated by a zone of relatively undisturbed field, which trends south-east from the northern to the southern boundary. This zone is associated with the sediments of the Toko Syncline. The Toko Syncline is represented on the magnetic basement contour map as a broad

asymmetric feature, steeply dipping on the south-western side and dipping more gradually on the north-eastern side. Maximum depths of over 20,000 ft are estimated in two small areas within a larger area where depths to magnetic basement of 16,000 ft are estimated. It will be shown that these depths are in general agreement with the conclusions reached from seismic results obtained in the Toko Syncline. The steep south-western flank indicated by the magnetic results is in agreement with geological evidence from the Toomba Range that the south-western margin of the syncline is faulted.

West of the Toko Syncline a magnetically disturbed zone fringes a region of near-surface magnetic basement. The anomalies, with amplitudes of up to 1500 gammas, could only be associated with basic rocks. However, little is known of the geology of this region as it is almost entirely covered by the sands of the Simpson Desert. The gravity results indicate a gravity 'high' in this south-west corner of the area, which tends to support the interpretation of magnetic results in terms of near-surface basement rocks.

East of the Toko Syncline two regions of shallow magnetic basement with north-south trends are evident at longitudes 139° and 139° 20'. The westernmost region corresponds to the outcrop area of the Lower Cambrian Sylvester Sandstone and the Sun Hill Arkose, where magnetic basement is estimated at 1000 to 2000 ft below sea level. The easternmost region of shallow magnetic basement has no surface expression and Cretaceous sediments are seen in outcrop.

Between these two regions a magnetic basement trough attains a maximum depth of 7500 ft. This trough, and a small basin feature on its southern extremity, coincides with the extension southwards of the Glenormiston Gravity Low. These magnetic and gravity features could indicate a thickening of sediments, but it is also possible that they may be caused by low density granite basement.

Seismic surveys

Papuan Apinaipi Petroleum Co. Ltd and Phillips Petroleum Company conducted work in 1960-61 in the Springvale, Boulia, and Toko Range areas (Phillips Petroleum Company, 1961). Also in 1960 the South Australian Department of Mines conducted a seismic survey in the Great Artesian Basin in South Australia and in Queensland as far north as Boulia (Milton and Seedsman, 1961). In 1963-64 the French Petroleum Company (Aust) Pty Ltd conducted a seismic survey which extended across the southern part of the Simpson Desert from South Australia to the Annandale - Sandringham region of Queensland and from there across to Coorabulka and Betoota (French Petroleum Comapny (Aust) Pty Ltd, 1965).

Much of the work carried out in the Springvale - Middleton area by Phillips Petroleum Co. lies to the east of the area covered by this report and so will not be considered here. In the extreme west of the region, in the Netting Fence area of the Toko Syncline (about 40 miles west of Glenormiston), correlation reflection shooting with split spreads of 950-0-950 ft, from 4 to 32 geophones per trace, 1 to 5 shot-holes per shot pattern, and shot-point spacing of between $\frac{1}{4}$ and 1 mile, was reported to give

satisfactory results where the surface outcrop was the Ordovician Mithaka Shale Formation. On Ordovician Nora Shale outcrops results were poor, but it was believed by the geophysical contractor that with improved techniques, such as the common-reflection-point compositing method, usable results could be obtained.

A well-defined structural 'high' in Cambrian and Ordovician rocks was indicated around 22° 55' south and 138° 02' east. The closed area of the structure covers about two square miles and maximum closure is about 250 ft. About 6500 ft of sedimentary section was indicated and this was confirmed by the drilling of P.A.P. Netting Fence No. 1 well (Papuan Apinaipi Petroleum Company Ltd, 1965). The seismic structure corresponds closely with a definite surface feature (the Netting Fence Structure). South-east of the above feature reliable data indicate that uniform southward dip persists throughout the area surveyed.

An east-west seismic traverse consisting of correlation shots one or two miles apart from the Netting Fence area to Glenormiston yielded no usable data. A similar traverse from Marion Downs south-west towards the Toko Syncline, passing through Watchie Hut, generally yielded no data. Intermittent reflections were recorded in certain localities, however, notably on the extreme south-western end of the traverse, but these were often not correlateable. In the Canary area (32 miles north-west of Springvale, Plates 1 to 3) several good reflections were obtained, including one believed to originate at or just above the base of the Mesozoic section. The reflections from below this horizon indicated a possible thickness of sediments of the order of 10,000 ft.

The seismic survey made by the South Australian Department of Mines in 1960 was along the Maree - Birdsville - Boulia Road, with a tie to Betoota and Cordillo Downs from Birdsville. The survey consisted of a series of short refraction depth-probes and some jump correlation reflection profiling using two-mile spacing between shot-points. The results from the refraction lines at Boulia, Breadalbane, Kamaran Downs No. 3 Bore, Cluny (about 18 miles south-east of Bedourie) and Roseberth (about 16 miles north-east of Birdsville), as well as the reflection lines from Birdsville to Breadalbane, are of interest to the survey described in this report.

The deepest correlateable reflection, designated 'reflection Z' by the South Australian Mines Department, occurs over most of the southern part of the survey area, and is believed to originate from the base of the Mesozoic section. North of Breadalbane the reflection is too shallow to be recorded but to the south it is seen as a continuous correlateable event with reflection times ranging from 0.17 second at Breadalbane to 1.59 seconds at Birdsville. On the refraction lines at Cluny No. 4 Bore, Old Roseberth, and New Roseberth, refractors with velocities of 19,400 ft/s, 19,400 ft/s, and 18,400 ft/s respectively occur at approximately the same depth as the 'Z' reflection. To the north however, at Cluny airstrip, a refractor with a velocity of 18,300 ft/s at 2400 ft is shallower than the 'Z' reflection, and at Breadalbane the high speed refractor with 17,900 ft/s velocity is at a depth of 1820 ft, which is considerably deeper than the 'Z' reflection. These facts suggest that the event labelled 'Z' may not always represent the same stratigraphic horizon.

The Boulia refraction line indicates a refractor at a depth of 300 ft with a velocity of 18,000 ft/s associated with dense limestones of early Palaeozoic age. It was postulated that this refractor was the same as the 17,900 ft/s refractor at a depth of 2000 ft at Breadalbane 70 miles to the south. From Breadalbane as far south as Bedourie, deep reflections occur down to a depth of 5000 ft below the level of this refraction horizon. It is thus concluded that there is a possibility of the occurrence of Cambro-Ordovician sediments at a depth of 2000 ft at Breadalbane.

On the refraction line at Kamaran No. 3 bore a velocity of 18,500 ft/s was recorded from granite at a depth of 1500 ft. This is possibly on the western, upthrown side of a fault marking the western edge of the southern extension of the Toko Syncline.

The French Petroleum Co. (Aust) Pty Ltd made seismic surveys in the Great Artesian Basin and the south-eastern portion of the Georgina Basin during 1963 and 1964. Much of the work done in 1963 in the Simpson Desert is too far from the area covered by this report to be of interest and so will not be considered here. The main part of the work done in the Georgina Basin was over the buried southern extension of the Toko Syncline. The structure in this area was well delineated and the south-eastern end of the Toko Syncline now appears to be a large monocline limited westward by a major fault. The eastern margin is also faulted and a major north-south fault separates the deep zone of the syncline from the eastern margin, which is characterised by west dips of about 20 degrees. In the eastern marginal zone the westerly dipping sediments of the Toko Syncline rapidly pinch out under the nearly horizontal Mesozoic cover. Results are poor in this area of pinch out and faulting may occur.

To the east of the southern part of the Toko Syncline the general features of an area of Cambrian sediments overlain by Mesozoic were outlined. This area, extending approximately 25 miles east of the eastern margin of the Toko Syncline, is situated mainly north of Bedourie. Immediately south-west of Bedourie a more or less circular zone of deep sedimentation about 12 miles in diameter was indicated. East of the area of Cambrian sediments north of Bedourie no continuous reflections were recorded from below the unconformity at the base of the Mesozoic except in two small areas.

In the Sandringham - Coorabulka region several reconnaissance traverses were surveyed and this was followed up by more detailed surveying of the Toko Syncline and its margins. Four main reflections were plotted in the region. They were designated the 'C', 'Z', 'N', and 'X' horizons and are believed to originate from the Jurassic - Cretaceous Transition Beds, the base of the Mesozoic, the Ninmaroo Formation, and from near the base of the Cambrian sediments (or possibly within the Upper Proterozoic) respectively.

Seismic work by French Petroleum Company (Aust) Pty Ltd indicated that the Toko Syncline is limited to the south-west by a fault with a displacement of more than 15,000 ft. Owing to a wide zone in which the results are very poor the exact location of the fault is hard to determine. The downthrow of the fault along the eastern margin increases to the south. Within the limits of these faults all horizons below the 'Z' horizon dip regularly to the

south-west with the thickness of the beds increasing slightly with depth. Correlateable reflections could be picked down to 2.6 to 3.0 seconds. The 'N' horizon, which is the strongest reflector in the syncline, occurred at a depth of about 15,500 ft. It was possible to correlate the 'N' horizon across the eastern fault that separates the deep zone of the syncline from the marginal zone.

The horizontal refraction velocity of the 'Z' horizon in the Toko Syncline area ranges from 11,500 to 14,400 ft/s. In this region the Mesozoic reaches a maximum thickness of 2300 ft. The 'C' horizon was recognised only in the south of the syncline, elsewhere it was too shallow to be followed in continuity.

The eastern margin of the Toko Syncline is a long, narrow strip extending from north to south. The 'Z' horizon from near the base of the Mesozoic is nearly horizontal but all horizons below it have a steep westerly dip of from 15 to 20 degrees. Correlateable reflections can be picked down to only 2 seconds in this area.

In the area immediately to the east of the Toko Syncline the 'N' horizon is not recognisable, but horizon 'X' can be picked at reflection times ranging from 0.9 to 1.5 seconds. It is not persistent over the whole area and is often hidden by multiples, possibly originating from the 'Z' horizon. The relationship of this area to the Toko Syncline edge is not known since a zone of poor quality reflection, possibly due to faulting, precludes any chance of relating the 'X' horizon directly to the 'N' horizon. The Brothers stratigraphic well, drilled by French Petroleum Co. (Aust) Pty Ltd about 10 miles north-west of Bedourie in this area (Plate 2) indicated that the Mesozoic sediments were underlain by Upper to Middle Cambrian limestones. It is therefore possible that the 'X' horizon, near the base of the Cambrian sediments, provides an indication of the extent of the Bedourie Cambrian basin or 'Cambrian block'. In this area the 'X' horizon corresponds to the deepest refractor recorded. The 'Z' horizon in the area is a very strong reflector and has a horizontal refraction velocity (14,750 to 18,500 ft/s) much higher here than in the Toko Syncline.

No continuous reflections were picked below the 'Z' horizon east of the 'Cambrian block', except in the gravity 'low' south of Coorabulka (Plate 3) and in an area south of Marduroo No. 1 stratigraphic hole, drilled by French Petroleum Co. (Aust) Pty Ltd about half way between Bedourie and Coorabulka. The horizontal refraction velocity of the 'Z' horizon ranges from 16,600 to 20,000 ft/s and is generally greater than 19,000 ft/s. Results obtained from Marduroo No. 1 stratigraphic hole indicate that this is an area where Mesozoic sediments rest directly on the Proterozoic. Above the 'Z' horizon two or three other reflectors can be picked, one of which is the 'C' horizon. The Mesozoic sediments have a regular and general dip to the south.

In the gravity minimum about 20 miles south of Coorabulka, reflections can be picked down to 2 seconds. The first strong reflector was labelled 'N?' as it was similar in character to the 'N' reflection recorded in the Toko Syncline. Along a north-south line the reflectors had a steep north dip component and along an east-west line the dip component was west. The French Petroleum Co. (Aust) Pty Ltd considers that there may be a Palaeozoic basin

in this area, but only its southern limit, which extends on to AT 66-67P was investigated. It was also considered by the Company that there may be a shallow Cambrian(?) basin centred about 15 miles south of Marduroo No. 1 Bore.

A reconnaissance traverse was shot to tie results in the area east of Bedourie to Betoota No. 1 Bore. Four continuous horizons were followed, the deepest of which corresponded to the 'Z' horizon. The horizons are conformable and dip gently southwards until they begin to rise towards the Betoota dome. The 'Z' horizon reaches a maximum depth of 6500 ft ten miles north of Betoota.

4. OBJECTIVES OF SURVEY AND PROGRAMMES

The survey was done in two parts: during the 1963 and 1964 field seasons, each of which consisted of the autumn, winter, and spring months. The overall objectives of the survey were defined before the 1963 field season and the objectives of the part of the survey done in 1964 were formulated with the aim of completing the programme started in 1963. However, since in practice each part of the survey was organised separately from the other it will be convenient to consider the objectives and planned programmes for the two parts separately.

Objectives for 1963

The objectives of the seismic survey were:

1. To carry out experimental work to determine and develop the most suitable reflection and refraction techniques for use in the area.

2. To investigate the structure of the Toko Syncline in the outcrop area south-west of Glenormiston and to determine the depth of sediments.

3. To determine whether the sediments of the Toko Syncline extend south-east from the most southerly outcrop area to Sandringham and Bedourie, as suggested by a large negative gravity anomaly with south-east trend. If so, the survey would try to determine the quantities of sediments present in the southerly extension of the Toko Syncline.

4. To determine whether Palaeozoic sediments similar to those in the Toko Syncline extend under the Great Artesian Basin in the vicinity of the negative gravity anomaly that occurs near the centre of the Birdsville 1:250,000 map area.

5. To attempt a stratigraphic tie between the Upper Proterozoic sediments near the head of Sylvester Creek and those encountered in Canary No. 1 Bore, and also to determine if there is any significant thickness of Cambro-Ordovician sediments between these two areas.

6. To determine or confirm major basic structure in other critical places that may be indicated as the work proceeds, with a view to assisting in the evaluation of the oil potential of the area.

Planned programme for 1963

On the assumption that access to the survey area would not be too difficult, the following programme was drawn up in 1963 to achieve the above objectives:

(a) A reconnaissance reflection traverse, across the Toko Syncline and the associated gravity minimum, to the south-west of Glenormiston, or in some other similar suitable location.

(b) A reconnaissance reflection traverse, across the extension of the gravity minimum to the south-east, approximately through Sandringham, to investigate the possible extension of the Palaeozoic sediments of the Toko Syncline into the area.

(c) A considerable amount of experimental work, on the study of interfering noise and the general improvement of reflection record quality, to be done in conjunction with the above reflection traversing in areas where record quality is generally poor.

(d) A refraction depth probe to measure all refractors to basement, if possible, to be carried out along the axis of the Toko Syncline and the gravity minimum.

(e) A reconnaissance reflection traverse along the axis of the Toko Syncline and the associated gravity minimum to provide a tie between (a) and (b).

(f) A reconnaissance reflection traverse from the south-western end of (b) south to Annandale, where there is a gravity 'low', to investigate the possible extension of the Palaeozoic sediments of the Toko Syncline into the Great Artesian Basin.

(g) A reconnaissance reflection traverse from near Sandringham to Bedourie to investigate the possible extension of the Palaeozoic sediments in that direction and to tie to the South Australian Mines Department traverse.

(h) A reconnaissance reflection and refraction traverse between areas of Upper Proterozoic outcrops near the head of Sylvester Creek and Canary No. 1 Bore to provide a tie between the two areas.

(i) Refraction depth-probes at critical places indicated by the above work to determine or confirm major basin structure.

Actual programme in 1963

After discussions with BMR geologists and geophysicists who were familiar with the area, it was concluded prior to the commencement of the survey that some of the above traverses would not be possible using conventional vehicles because of the difficulty of access to the sand-ridge country west of the Mulligan River. In particular it was decided that, as (a) presented difficulties of access south-west of Glenormiston, this traverse should be located along a track running south-west from Marion Downs through Watchie Hut to Pulchera Waterhole.

When the seismic party arrived in the Boulia area it was found to be impossible, as a result of flooding, for vehicles to cross the Georgina River to gain access to the Toko Syncline area. This situation applied for four weeks. While waiting for the Georgina River to subside, the seismic party carried out reflection and refraction work between Marion Downs station and Phillips Canary No. 1 Bore, as part fulfillment of item (h) of the programme. Refraction depth-probes were done on four traverses between the Georgina River and Canary. Two of these were situated in areas of gravity anomalies, one positive and one negative. The positions of the traverses are shown in Plate 2. Three and a half miles of continuous reflection profiling was done on Traverse A, using 600-ft geophone-spreads in order to record shallow reflections. A short reflection profile was also shot on Traverse D, which passed through Canary No. 1 Bore, for correlation with the bore and for comparison with Traverse A.

On 23rd May, the party was able to cross the Georgina River and transfer its attention to the Toko Syncline about 25 miles north-west of Sandringham.

To fulfil item (a) of the programme, a continuous reflection traverse (Traverse F) with 1800-ft geophone-spreads, was surveyed from near Yarrandilla Yard on the north-eastern margin of the syncline to the south-west for thirty miles, past the southern end of Pulchera Waterhole and across the south-western margin of the syncline. About a quarter of this reflection traverse was duplicated using 600-ft spreads to attempt to record shallow reflections. Some shallow refraction work was done near the south-western end of the traverse to assist in the location of suspected faults. Some noise tests and other experimental work were also done on this traverse.

Traverse E was surveyed roughly at right angles to Traverse F in the deepest part of the Toko Syncline in this area (Plate 2). A refraction depth-probe to record all refractors was shot on this traverse near Traverse F using shot-to-geophone distances from zero to 10½ miles and shooting from both directions.

Three separate sections of continuous reflection profiling, totalling sixteen miles, were also shot on Traverse E. A velocity profile consisting of nine 1800-ft spreads was also shot on this traverse where it intersects Traverse F.

Because of poor results on parts of Traverse F in the Pulchera area and difficulties in interpretation, it was necessary to undertake some additional, unplanned work. Reflection Traverses M and L, four and seven miles long respectively, were surveyed in order to complete a rectangular loop with portions of Traverses E and F near the tectonically complicated western margin of the Toko Syncline. Traverse P was a short refraction traverse crossing Traverse F near its south-western end.

Traverse G was a two mile reflection cross-traverse perpendicular to Traverse F. Traverse H was a velocity profile shot at right angles to Traverse F. Traverse I was a short, shallow-refraction profile. Traverses J and K were short refraction-probes shot on the Proterozoic outcrop area north-east of Watchie Hut to measure the refraction velocities of the Sun Hill Arkose and Sylvester Sandstone respectively. Traverse Q was a three-mile reflection traverse near Hilary Dam surveyed as a link between the Yarrandilla and Marion Downs area.

The locations of all these traverses are shown in Plate 2.

Because of the extra work done as an outcome of the results obtained during the course of the survey, little time remained towards the end of the survey for completion of items (b), (f), and (g). This work was not started as it was learned that the French Petroleum Co. (Aust) Pty Ltd intended to do a considerable amount of seismic work in the Sandringham - Bedourie area and it appeared that this work would achieve the objectives of the BMR programme. There was insufficient time to complete item (i).

In fulfillment of item (c) of the programme, a certain amount of experimental work was done. Of three weeks spent on purely experimental work, $2\frac{1}{2}$ weeks were devoted to reflection work. This included four separate series of noise measurements, trials of various shot-hole, geophone, and spread arrangements, and experiments with collinear offset shots. The intended programme of experimental reflection work was carried out and reflection quality was good.

The unexpectedly good reflection results reduced the need for extensive refraction work. As refraction profiling on a large scale was not required, techniques for its use were not fully explored. One persistent, high-velocity refractor in the Toko Syncline was detected, but experimental refraction work was confined to comparing the results of shots made on the surface with shots made down shot-holes and to comparing the explosive mixture of ammonium nitrate and fuel oil with 'Geophex'.

Objectives for 1964

The broad objectives of the 1964 survey were firstly to complete the stratigraphic tie between the Upper Proterozoic sediments at Sylvester Creek and Canary Bore, which was started during the 1963 survey, and secondly to carry out experimental work on Traverse F (1963) in an attempt to eliminate multiples and improve primary reflections below the Ninmaroo reflections.

In order to carry out the first part of the programme the following were regarded as detailed objectives whose attainment would allow solution of the problems

1. To establish a reliable technique for recording shallow and deep reflection markers when shooting on outcropping Lower Palaeozoic formations or when there is a thin cover of Mesozoic, Tertiary, or Recent sediments over the Lower Palaeozoic sediments.

2. To determine if the high velocity refractor on Traverse A represented rocks of Lower Palaeozoic age or crystalline basement.

3. To establish the stratigraphic relation between the high velocity refractor recorded on Traverse A (1963) and the sediments of Canary No. 1 Bore and those outcropping near Sylvester Creek.

4. To determine the relation between the gravity anomalies of the southern part of the Cloncurry Gravity High and the basement or sedimentary structure.

Planned programme for 1964

The original programme drawn up in 1964 to achieve the above objectives was as follows:

(a) To carry out experimental work near Herbert Downs on outcropping Lower Palaeozoic sediments in order to determine the best reflection techniques to be used to obtain reflection markers within and below the Lower Palaeozoic.

To measure the refraction velocity of the dolomites within the Ninmaroo Formation over a distance of at least three miles.

To determine whether the Ninmaroo Formation, or other Lower Palaeozoic sediments, include refraction markers that could be followed to the south-east beyond the outcrop area.

(b) Depending on the results of the above experimental work, to shoot a reconnaissance traverse from the Herbert Downs Lower Palaeozoic outcrop area south through the Glenormiston Gravity Low to tie with Traverse A (1963).

(c) To provide a seismic tie between Traverse A and Traverse D (1963). The method used was to depend on the results of (a) and (b).

(d) To provide a seismic tie between Traverse A and the north-western end of Traverse F (1963). Again the method used was to depend on the results of (a) and (b).

(e) To shoot one or more velocity spreads on the northern half of Traverse F in an attempt to determine average velocity relationships for primary and multiple reflections with a view to distinguishing multiples.

(f) To carry out experimental shooting directed towards elimination of multiple reflections from the deeper part of the seismic cross-section and the solution of any other problems arising out of the study of the 1963 results.

Actual programme in 1964

In order to carry out programme proposal (a) a short traverse (Traverse N) was surveyed east of Herbert Downs on an outcrop of the Ninmaroo Formation, using 1800-ft intervals between shot-points (see Plate 2). Noise tests were carried out at SP 6005 to determine the optimum spacing for geophone groups and shot-hole patterns. This traverse was shot continuously using both the refraction and reflection methods. No reflections were recorded.

Traverses O and R (Plate 2) were surveyed through the Glenormiston Gravity Low (Gibb, 1966) in an effort to tie with Traverse A (programme item (b)). Attempts to follow the Ninmaroo Formation by means of continuous refraction profiling on Traverse O were unsuccessful so that this part of the programme was abandoned. Two reflection spreads were also shot on Traverse O but without results. After a series of noise tests on Traverse R at SP 6718, two miles of continuous reflection profiling were shot between SP 6716 and SP 6722. Further reflection work was not carried out owing to the poor results obtained.

As it was known that good reflections could be obtained in the vicinity of Canary Bore it was decided to commence programme item (c) in this area. Traverses V, B, and S (Plate 2) were shot using the continuous reflection profiling method, the total distance involved being 45 miles. Two series of noise tests were carried out on Traverse V. In order to clarify the refraction results obtained on Traverses B, C, and D in 1963, two short refraction probes were also shot on Traverse V. A scout hole was drilled to a depth of 470 ft on Traverse A (1963) to identify a refractor recorded on this traverse.

Programme item (d) was partially completed by the extension of Traverse A to connect with Traverse Q, a distance of 24 miles (Plate 2). The continuous reflection profiling method was employed on this traverse using a shot-point interval of 900 ft. Owing to the lack of time available, the tie between Traverses A and F (1963) could not be completed.

A total of three velocity spreads, on Traverses T, U, and W, each consisting of nine 1800-ft spreads were shot at intervals across Traverse F (programme item (e)) to supplement two velocity spreads shot on Traverse F in 1963.

Experimental shooting in the form of the roll-along multiple-coverage method was employed between the 1963 shot-points SP 186 and SP 232 on Traverse F (programme item (f)). Shooting 300 ft from the end of the spread between SP 232 and SP 217, and 900 ft from

the end of the spread between SP 186 and SP 214½, twelve-fold subsurface coverage was obtained. The presence of several sand dunes in the interval between SP 214½ and SP 217 made coverage of this area impractical. Severe dust storms and then heavy rain delayed the completion of this part of the programme.

5. RESULTS AND INTERPRETATION

A. RECONNAISSANCE TRAVERSES BETWEEN MARION DOWNS AND CANARY

Refraction Traverses A, B, C, D, and V

Refraction results on Traverses A, B, C, D, and V are summarised in Plate 5, which shows the intercept times for the various refractors that were recorded and also approximate depth estimates for the refractors. Refraction depth-probes similar to the type described by Vale and Smith (1961) were made on Traverses A to D using 7200-ft geophone spreads. On Traverse V, two 3½-mile refraction profiles were shot continuously in both directions between SP 7647 and SP 7667 (V_1) and between SP 7765 and SP 7785 (V_2), using geophone spreads 3600 ft long. The corrected time/distance plots for Traverses A to D and V_1 and V_2 are shown in Plates 6 to 12.

Interpretation of the refraction probes in terms of depth and stratigraphy has been assisted by the information provided by continuous reflection profiling carried out along the traverses and by a limited amount of borehole information. However, depth estimates remain speculative owing to the lack of vertical velocity information, except on Traverse D and to a lesser extent on Traverse A. A well geophone velocity survey was made in BMR Marion Downs No. 1 Scout Hole on Traverse A, from the surface to a depth of 325 ft (for details see page 30). Traverse D was surveyed in an east-west direction through Phillips Canary No. 1 Bore (at SP 1307) in which a continuous velocity log was run between depths of 558 and 3200 ft. Because of the velocity information available from Canary No. 1 Bore it is preferable to consider the results on Traverse D first.

Refraction Traverse D. It can be seen from Plate 9 that for Traverse D there is good agreement between the time/distance graphs for direct and reverse shots, indicating that the refractors are near-horizontal.

There is a sudden increase in velocity from the sub-weathering value of about 7000 ft/s to 14,200 ft/s at a distance of 1100 ft from the shot-point. The depth to the interface represented by this discontinuity is calculated as 500 ft below the surface, which agrees closely with the depth (492 ft) to the top of the Upper Proterozoic sediments encountered in the Canary No. 1 Bore immediately below the Cretaceous artesian sequence. Beyond this change, however, the time/distance graph shows no marked velocity discontinuities. Although in Plate 9 the time/distance graph has been divided into a number of straight-line segments representing velocities of 14,200, 15,700, 16,700 and 17,650 ft/s, the division of the last three segments is rather arbitrary.

The straight line segments were treated as representing distinct refractors in order to obtain an approximate idea of the velocity-depth relation and to allow comparison with the results of

other refraction probes. Calculations were made using an average overburden velocity method, the average velocities between the surface and the refractors being obtained from the integrated continuous velocity log of Canary No. 1 Bore. The depths (below datum) obtained for the various refractors are illustrated on the lower half of Plate 5. The depth below the surface of the deepest refractor recorded, with a velocity of 17,650 ft/s, is of the order of 1900 ft.

The time/distance graph for Traverse D could be approximated by a smooth curve representing continuous increase in velocity V with depth Z equally as well as by a number of straight-line segments. Plate 10 is a time/distance graph for Traverse D, with the effects of the shallow 7000-ft/s layer removed. To determine a mathematical function that would approximate the curve obtained in practice it was assumed that the velocity function to fit the curve was of the form $V = Vo + KZ$, and the constants Vo and K were determined by the method described by Dix (1952, p. 116). Vo was found to be 13,580 ft/s and K was determined to be 1.2 sec^{-1}. Using these values, a calculated time/distance graph was drawn on Plate 10 for comparison with the actual field curve. It can be seen that the calculated curve is in close agreement with the field curve. However, velocity-depth relationships calculated from both the straight segment and smooth curve approximations of the field time/distance graph are in disagreement with those obtained using data from the continuous velocity log in Canary No. 1 Bore.

The continuous velocity log shows a fairly gradual increase in velocity from 10,600 ft/s at 560 ft to 12,800 ft/s at about 1500 ft. The only significant departures from this general trend are for thin beds, which would not be recorded by the refraction method. There is a slight decrease in velocity below 1500 ft, to about 12,200 ft/s at 1800 ft, but essentially the log shows a fairly constant velocity of about 12,800 ft/s from 1500 to 2600 ft. There is a significant increase at 2680 ft to about 14,700 ft/s, and from there to the bottom of the hole the values vary between 14,000 and 16,000 ft/s.

Although the refraction probe results are consistent with the continuous velocity log in suggesting a gradual increase in velocity from about 500 to 1500 ft, the magnitudes of refraction velocities obtained are generally 25 to 30 percent higher than the maximum logged velocities from about the same depth. This suggests either a large degree of anisotropy in the rocks in the area to a depth of 1500 ft, the vertical velocities as measured in the bore being considerably less than the horizontal velocities measured by refraction, or else the sedimentary section drilled at the bore site was not a typical sample of the rocks in the area. The refraction measurements sampled refraction velocities over an interval of about one mile in the east-west direction. It is probable that the explanation lies in anisotropy since horizontally stratified rocks do commonly exhibit higher velocities in the horizontal than in the vertical direction.

Refraction Traverse V_2 (SP 7765 to SP 7785). The results obtained on Traverse V_2 a few miles south-west of Traverse D are similar to those from Traverse D. The time/distance graphs for Traverse V_2 are shown in Plate 12 and it can be seen that there is good agreement between the time/distance plots for direct and reverse shots, indicating that the refractors are near-horizontal.

A sudden increase in velocity from the sub-weathering value of about 8400 ft/s to 13,500 ft/s occurs at a distance of 1500 ft from the shot-point. Beyond this distance there are, as in the case of Traverse D, no marked velocity discontinuities, but the time/distance graph has been divided into a number of straight-line segments representing velocities of 13,500, 14,650, 15,100, 16,400, and 17,150 ft/s. The depths for the various refractors, obtained using average velocity data from the velocity log of Canary No. 1 Bore, are illustrated in Plate 5.

Refraction Traverse A. Reflection shooting on Traverse A indicated an average first-break sub-weathering velocity of about 7000 ft/s, although this was quite variable. Two other refractors, with velocities of 16,150 ft/s and 19,000 ft/s were recorded on this traverse (Plate 6). A velocity survey carried out in the scout hole drilled on Traverse A indicated that the average velocity down to the 16,150-ft/s refractor was 8000 ft/s and that the refractor was at a depth of about 380 ft below the surface. This refraction event probably originates from a limestone entered by the drill at 360 ft. The limestone has been tentatively correlated with the Upper Cambrian Chatsworth Limestone (M. A. Reynolds, pers. comm.). The 19,000-ft/s refractor occurs at a calculated depth of about 900 ft below the surface. Arrival times for the shots from opposite directions differ somewhat, particularly for the 16,150-ft/s refractor, although the apparent velocities indicated are similar. This suggests that the refractor is near-horizontal but that there may be faulting on this traverse, the greater travel times being due to greater refractor depth under the shot-point or geophone in question.

Refraction Traverse B. The time/distance graphs for the shots from opposite directions on Traverse B agree approximately (Plate 7). A sub-weathering velocity of about 6000 ft/s was recorded. Two other refractors, with velocities of 16,100 ft/s and 18,400 ft/s were also recorded, from depths of about 550 ft and 950 ft below the surface, respectively.

Refraction Traverse V_1 (SP 7647 to SP 7667). The time/distance graph for Traverse V_1 is shown in Plate 11 and it can be seen that there is good agreement between the plots for direct and reverse shots, indicating that the refractors are near-horizontal. In addition to a sub-weathering velocity of 5800 ft/s, a refractor with a velocity of 17,000 ft/s was recorded on the traverse. It was calculated that this refractor was at a depth of about 480 ft below the surface.

Refraction Traverse C. The time/distance graph for Traverse C (Plate 8) shows that in addition to a sub-weathering velocity of 6900 ft/s, refraction velocities of 15,000 ft/s and 16,500 ft/s were recorded for both direct and reverse shots on this traverse. These refractors are calculated to be at depths of about 640 ft and 1000 ft below the surface, respectively. A refractor with an apparent velocity of 18,400 ft/s was recorded as a first arrival only for shots from the north-west of the spread. The depth of this refractor appears to be about 1700 ft below surface. For shots from the south-east of the spread, it was found that shot-point delay times decreased considerably as the shot-point was moved towards the south-east. For this reason it is postulated that the refractors become shallower from about SP 1210 towards the south-east end of the traverse.

Failure to record the refractor with an apparent velocity of 18,400 ft/s for shots from the south-east suggests that it is not present at the south-east end of the traverse. It seems likely that part of the traverse has been affected by faulting or folding or at least that the traverse crosses a district lithological boundary at a depth of about 1700 ft.

Depth estimates for the refractors on Traverses A, B, C, and V_1 were made using single average overburden velocities. The average velocities used were estimated. Although these estimates were guided by the results of the well survey in the scout hole on Traverse A and by some velocity information obtained from $t:\Delta t$ analyses of reflections on Traverses A, B, and V, the average velocities used are very approximate only, so that depth estimates could be up to 20% in error.

Interpretation of refraction results. Plate 5 shows that the refraction velocities recorded differ appreciably from traverse to traverse, so that correlation of the stratigraphic horizons from Traverse A to Traverse D on the basis of refraction data must be doubtful. It seems reasonable to assume that the sub-weathering velocity of about 6000 to 8000 ft/s recorded on each traverse represents Mesozoic sediments. This is certainly the case on Traverses A and D, where rocks with these velocities are known from the bores to be of Lower Cretaceous age. Moreover, continuous reflection profiling between the two bores produced a reflection occurring at between 0.1 and 0.2 second (corresponding to depths between 300 and 650 ft), which can be followed across all the cross-sections (Plates 14, 15, 18, and 21) and which is probably associated with the pronounced velocity discontinuity marking the base of the Mesozoic sediments on each traverse. This reflection with associated velocity discontinuity is believed to be the equivalent of the 'Z' horizon referred to by Milton and Seedsman (1961) and the French Petroleum Co. (Aust) Pty Ltd (1965). The thickness of the Mesozoic sediments is indicated by refraction work to range from about 370 ft on Traverse A to a maximum of about 640 ft on Traverse C.

It is not unreasonable to suggest that the 16,150-ft/s refractor on Traverse A may correspond to the 16,100-ft/s refractor recorded on Traverse B, and that the 19,000-ft/s refractor on Traverse A may correspond to the 18,400-ft/s refractor on Traverse B. If this correlation is correct, an increase in depth of the horizons represented by these refractors is indicated from west to east between these traverses. The 16,150-ft/s refraction event on Traverse A is believed to originate from a limestone that is considered to be of Upper Cambrian age. Although the deeper refractor with high velocity might represent relatively shallow Precambrian crystalline basement it is also quite possible that it represents a Lower Palaeozoic rock, since rocks of this age with refraction velocities of about 19,000 ft/s are known to occur 30 miles to the north-west and elsewhere in the Georgina Basin. Reflection work on Traverse A indicated that reliable primary reflections were recorded down to a depth of 1300 ft, which is probably below the depth of the 19,000-ft/s refractor recorded on this traverse. It is therefore unlikely that this refractor represents igneous basement.

Correlation of refractors on Traverses A and B cannot be extended through to Traverse V_1 and C, for on Traverse V_1 only one high velocity refractor was recorded in addition to the low Mesozoic velocity, whereas on Traverse C three separate high velocity refractors were recorded. Also, results on Traverse C show indications of tectonic disturbance, which might further complicate correlation with other traverses.

Plate 13 illustrates that the time/distance curves for Traverses V_2 and D are dissimilar to those for the other four traverses. The former indicate a gradual increase in velocity below the Mesozoic section rather than distinct velocity discontinuities, and the arrival times are greater for a given shot-to-geophone distance. It is known from Canary No. 1 Bore that the Mesozoic section on Traverse D is resting directly on rocks of Upper Proterozoic age. The similarity of the results obtained on Traverse V_2 to that obtained on Traverse D suggests that here also the Mesozoic section is resting on rocks of Upper Proterozoic age. Likewise the similarity of the results obtained on Traverses A, B, and V_1 suggests that there is a similarity in the pre-Mesozoic section on these traverses and that it is different from the pre-Mesozoic section on Traverses V_2 and D. The scout hole drilled on Traverse A showed that the top of the pre-Mesozoic section was of Lower Palaeozoic age and it is therefore probable that these Lower Palaeozoic sediments extend at least as far east as Traverse V_1.

It can be seen from Plate 13 that the time/distance graphs fall into two groups consisting of Traverses D and V_2 on the one hand and Traverses A, B, and V_1 on the other, while the graph for Traverse C lies in between the two. It has already been pointed out that there is evidence of tectonically disturbed conditions on Traverse C. It is possible that Traverse C lies in a zone of unique conditions for this area, separating regions to the east and west that have significantly different velocity characteristics and hence lithological differences.

Reflection Traverses D, V, B, and S

Techniques. Reflection Traverse D was a short profile of nine shot-points surveyed east-west through Phillips Canary No. 1 Bore in 1963. Short split-spreads extending 600 ft on either side of the shot-point were employed in order to record very shallow events. The shot pattern consisted of five holes in line parallel to the traverse, 60 ft deep and 25 ft apart, offset 50 ft from the traverse. Sixteen geophones per trace were used in line along the traverse with a spacing of about 20 ft.

In 1964 reflection Traverse V was surveyed from near Canary No. 1 Bore for about 30 miles to the west to link up with Traverses B, S, and A (see Plate 2). Split spreads extending 1800 ft on either side of the shot-point were employed, with a geophone station interval of 150 ft. However, successive shot-points were only 900 ft apart. This spread arrangement resulted in double sub-surface coverage of all reflecting horizons, thus enabling two-fold stacking of the records to be carried out. At the same time this shot/geophone arrangement was designed to allow a continuous cross-section to be made using only the centre twelve traces of each record. Such a

cross-section is much more favourable for the picking of shallow reflectors, since these reflections suffer interference by the early refraction arrivals at distances of more than about 900 ft from the shot.

Two series of noise tests were made on Traverse V, at SP 7676 and SP 7783 about 18 miles apart. The results are shown in variable-area record form in Plates 37 and 36, respectively. Graphs of frequency against wave number for all pickable noise events recorded at these and other noise test shot-points are shown in Plate 45. The relative amplitudes of the coherent noise events in decibels are indicated beside the plotted points on the graphs.

It is evident from Plates 37 and 36 that both noise tests indicated that the greater part of the shot-generated noise, perhaps 80% of the total, was of the coherent or organised type of noise. The transverse or cross-spread records on the plates indicated that only minor quantities of noise travelling at right angles to the traverse were generated. The noise test results indicated that linear shot and geophone patterns parallel to the traverse would be most effective in attenuating the greater part of the noise.

Traverse V was shot using five-hole shot patterns, the holes being 50 ft apart in line along the traverse, and 24 geophones per trace in two rows of 12, 20 ft apart in line along the traverse. The interval between geophones was $12\frac{1}{2}$ ft. Similar shot-hole patterns were used on Traverses B and S, but the number of geophones per trace was increased to 32, in two rows of 16, and the spacing between geophones was reduced to $9\frac{1}{2}$ ft.

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

$$k_c = \frac{1}{2\ ne} \quad \text{(Smith, 1956)}$$

then the cut-off wave number for the shot-hole and geophone patterns mainly used on Traverse V is $k_c = 0.0020$ cycles/ft. It can be seen from the graphs for SP 7676 and SP 7783 in Plate 45 that spatial filters with such a cut-off point should be effective in attenuating the coherent noise recorded, which is plotted to the right of this wave number in the region of attenuation. The electrical filters in the recording equipment with low-cut frequency f_c should also be effective against a number of low frequency noise events recorded. The number of shot-holes per shot, and particularly the number of geophones per trace employed, were sufficient to ensure a considerable attenuation of random or non-coherent noise, which is reduced in proportion to the square root of the number of shot-holes or geophones employed.

A number of experiments were made on Traverse V at SP 7684 and SP 7667 to see if improvement in record quality could be obtained. To ascertain the effect of shooting depth on record quality, a five-hole pattern with the holes 50 ft apart was drilled to 150 ft at SP 7684. This pattern was shot at various depths from 150 to 45 ft, but little improvement in reflection quality with depth could be seen on the records. At SP 7667 a ten-hole pattern was drilled, the holes being in two lines of five holes 50 ft apart offset 75 ft each side of the traverse. Using a geophone station interval of 300 ft and

increasing the number of geophones per trace to 48, in two rows of 24, the pattern was shot first using all ten holes and then using only one of the rows of five holes. The records obtained were then compared with the record obtained using the normal shot/geophone arrangement. This comparison showed that the ten-hole pattern gave significantly better quality reflections. Reflections almost as good were obtained when shooting from only five holes into the spread with the 48 geophones per trace. It could be seen that for production work an improvement in results could have been achieved by using a greater multiplicity of shot-holes and geophones. However, it would have been difficult to use this greater multiplicity and at the same time maintain a reasonable rate of progress that would allow completion of the planned programme in the time allotted.

Traverse D results. It can be seen from Plate 14 that the strongest reflection, which was also the shallowest on Traverse D, was recorded at about 0.11 second corrected time (0.165 second uncorrected). It is very likely that this reflection is associated with the base of the Mesozoic sediments at a depth of 500 ft, where it is known that there is a marked velocity discontinuity. This strong shallow reflection, which is continuously correlateable, indicates little or no dip along the traverse. The second event that can be correlated from record to record was recorded at an uncorrected time of about 0.35 second. The fact that this time is double the surface-to-surface time for the strong shallow reflection suggests that the second event is a simple multiple of the first.

An event was recorded at about 0.55 second (corrected time) which can be correlated over practically the whole of Traverse D. This event indicates a very gentle dip to the east. It could also be a multiple reflection, although there is no strong reason to believe that it is. Another event which also indicates slight dip to the east was recorded at about 0.9 second (Plate 14). This event cannot be correlated across the whole traverse, but on a number of records it is characterised by four or five cycles of high frequency energy, which make it evident against a background of predominantly lower frequency noise. Another weak event, indicating little or no dip, was recorded at about 1.07 second.

A deeper event, indicating moderately strong east dip (about 25 degrees), could be correlated over six records. This event was recorded at 1.53 seconds at SP 1306-2/3 and 1.78 seconds at SP 1308-2/3. The event is too straight to be a diffraction unless the traverse is parallel to the strike of the diffracting feature and the amount of dip is such that it is unlikely to be a multiple of any of the near-horizontal events above it. It could be a reflected refraction. However, it is possible that this event is a genuine reflection, perhaps from within metamorphic or igneous basement or from deeper sediments unconformable with the gently dipping Proterozoic sediments above.

On the evidence of the horizontal or gently dipping reflections recorded at times of up to 1.07 seconds, it may be concluded that on Traverse D, Proterozoic sediments more or less conformable with those encountered in Canary No. 1 Bore extend to a depth of at least 7500 ft, assuming that the average vertical velocity below the bottom of Canary No. 1 Bore is about 16,000 ft/s. This is about the magnitude of the interval velocities recorded near the bottom of the bore.

Traverses V, B, and S results. The results of reflection Traverses V, B, and S are presented in the form of variable-area cross-sections in Plates 15 to 23. Plates 15, 18, and 21 are cross-sections of Traverses V, B, and S, respectively, made using only the centre 12 traces of each record, so that the spread length is restricted to 900 ft from shot-point to furthest geophone. Plates 16, 19, and 22 are cross-sections made using single coverage, 24 traces per record, and spread lengths of 1800 ft from shot-point to furthest geophone. Plates 17, 20, and 23 are cross-sections for the three traverses using 24 traces per record, 1800-ft spreads, and two-fold stacking applied in the usual manner for the common-depth-point method.

It can be seen from an inspection of the plates that the cross-sections using 900-ft geophone spreads (centre 12 traces) give the best quality data for shallow reflections recorded at times of less than about 0.5 second. The cross-sections for two-fold stacking show better shallow reflection data than do those for single coverage with 1800-ft spreads, but not so good as those for 900-ft spreads. As far as deeper reflections are concerned, the cross-sections for 900-ft spreads and those for single coverage using 1800-ft spreads show results of comparable quality. The cross-sections for two-fold stacking show no improvement in reflection quality over the other two types for the deeper reflections. Apparently the slight improvement to be expected from two-fold stacking was insufficient to offset some deterioration caused by the application of imprecise corrections before stacking.

The shallow reflection recorded from near the base of the Mesozoic at 0.11 second on Traverse D is also evident at the western end of Traverse V, which links up with Traverse D. Although there are some breaks in continuity on the cross-sections, this reflection is recorded over most of Traverses V, B, and S. Reflection times range from about 0.1 to 0.2 second (uncorrected), corresponding to depths of about 300 to 650 ft below the surface. In places, a fairly weak multiple of this reflection appears to have been recorded at about twice the reflection time.

On the western end of Traverse V, as on Traverse D, reflections indicating horizontal or gently dipping sediments were recorded up to corrected reflection times of about 1.1 second. None of these reflections was very strong except for the shallow reflection associated with the base of the Mesozoic. From SP 7799 at the western end of Traverse V to about SP 7720, reflections at about 0.5 second indicate practically horizontal sediments. From about 0.5 to 1.1 seconds reflection time over this same interval, reflections indicate a gentle dip to the east except near SP 7763 and SP 7747, where there are small dip reversals, which give rise to anticlines of very low relief. For about a mile west of SP 7720, reflections indicate increasing easterly dip, but in the vicinity of SP 7716, reflections below 0.5 second terminate fairly abruptly. This disappearance of the deeper reflections may be due to faulting in this area or to some other reason, as will be discussed later.

Between SP 7714 and SP 7684, few reflections were recorded from below the Mesozoic. However, a few poor reflections between 0.2 and 0.5 second indicate easterly dip between SP 7710 and

and SP 7705, more or less horizontal sediments from SP 7700 to SP 7690 and westerly dip to the west of this. Between SP 7684 and SP 7677, reflections recorded at about 0.4, 0.5, and 0.6 second indicate a definite westerly component of dip of about 14 degrees.

It is clear that between SP 7720 and SP 7677 the pre-Mesozoic sediments exhibit some sort of structural 'high' with axis in the vicinity of SP 7694 and SP 7702 and appreciable dips to the east and west on the flanks. However, it can be observed from Plate 3 that this structural feature coincides approximately with a small gravity minimum which is part of an extensive elongated gravity 'low' trending in a north-north-west direction and passing just east of Boulia. This gravity 'low' is described by Gibb (1966) and is shown as feature 1 in Plate 4. Its northern end coincides with exposures of the Kalkadoon Granite, which is actually a low-density granodiorite. Gibb states that it is almost certain that the granodiorite, bounded by higher-density Precambrian rocks, is the source of the gravity 'low'. If this explanation is accepted then the Kalkadoon Granite, as delineated by the Kalkadoon Gravity Low, extends to the south far beyond the outcrops in the south of the Duchess 1:250,000 map area. Gibb states that a calculated anomaly curve agrees favourably with the residual gravity curve across the Kalkadoon Gravity Low when a density contrast of 0.13 g/cm^3 is used between the lighter postulated granitic mass (2.70 g/cm^3) and the denser surrounding medium (2.80 g/cm^3).

Gibb's postulate, when applied to Traverse V in the vicinity of refraction Traverse C, provides a plausible explanation for the fact that an apparent structural 'high' indicated by seismic results is accompanied by a gravity 'low', a fact that would be difficult to explain otherwise. It seems probable that the pre-Mesozoic sediments in this area, most likely Upper Proterozoic in age as in Canary No. 1 Bore, were folded into an anticline and partly intruded by a mass of comparatively low density igneous rock. The termination of reflections below 0.5 second near SP 7716 already mentioned may be due to intrusion of the sediments by the igneous mass west of here. Because of the scarcity and poor quality of reflections in the vicinity of SP 7694 to SP 7702 it is difficult to estimate the depth to the top of the supposed igneous mass with accuracy. It appears that there are probably no genuine reflections in this area beyond about 0.45 second, so that the top of the igneous mass could be about 2300 ft below datum.

Refraction Traverse C was surveyed to the south-east from near SP 7693 on Traverse V, so that the former traverse is approximately on strike with the structural 'high' on Traverse V described above. It has already been pointed out that refraction results indicated that conditions on Traverse C were different from those on refraction Traverses A, B, V_1, V_2, and D and also that Traverse C is in an area of lithological discontinuity at the level of the deepest refractor recorded. It is possible that the deepest refractor, with apparent velocity of 18,400 ft/s, which was recorded only on the north-western half of the traverse, represents the low-density igneous rock postulated to occur beneath Traverse V a few miles to the north.

Between SP 7675 and SP 7670 on Traverse V, reflections are very poor to absent, so that it is impossible to correlate the west-dipping reflections on the western flank of the structural 'high'

to the east with reflections further west. From SP 7670 to SP 7657, reflections recorded at times of up to about 1.0 second indicate horizontal sediments or east dip. West of SP 7657, reflection results on Traverse V are very poor, with the exception of the shallow reflection associated with the base of the Mesozoic.

On Traverse B, reflections indicating more or less horizontal strata or gentle dip to the west were recorded at times of up to about 0.7 second, although the quality of these reflections were generally poor. Reflection quality was also poor on Traverse S, but the events that can be correlated for any distance on this traverse indicate little or no dip.

On each of reflection Traverses V, B, and S a number of steeply dipping events were recorded at times generally exceeding 1.0 second. For example at the western end of Traverse V an event indicating a considerable north-easterly component of dip was recorded at about 1.1 second at SP 7791 and 1.6 second at SP 7799. This is probably the same dipping event as was recorded on Traverse D. Many such events were recorded, some indicating east dip and some indicating west dip. It is most probable that they originate from folded metamorphic rocks below and unconformable with the horizontal or gently dipping sediments which underlie the Mesozoic. It is also possible that they originate from igneous rocks. On some parts of Traverses V and B the reflection cross-sections give some indication of the depth of the strong unconformity or other type of discontinuity which must exist. On the western half of Traverse V, for instance, the strongly dipping events begin to be recorded after about one second, which is also about the limit for the recording of the gently dipping, correlateable reflections. On the western end of Traverse B there are similar indications that an unconformity or other type of discontinuity is recorded at about 0.75 second (4,500 ft), but on other parts of Traverses V and B and on the whole of Traverse S, which is probably surveyed more or less along the strike of the deep, strongly folded rocks, the reflection results give little or no indication of the depth of the unconformity.

BMR Marion Downs No. 1 Scout Hole, drilled on Traverse A near the northern end of Traverse S, indicated the presence of Cambrian limestone beneath the Mesozoic sediments at the surface. Canary No. 1 Bore at the western end of Traverse V indicated Upper Proterozoic sediments beneath the Mesozoic. The eastern limit for the occurrence of Palaeozoic sediments must therefore be somewhere on the reflection traverses shot between these two holes, but the reflection traverses give no firm indication of where this limit occurs. This is not surprising considering the generally poor quality of results and the fact that the Palaeozoic sediments can be expected to be more or less conformable with the horizontal to gently dipping Proterozoic sediments. The refraction traverses in this area indicate significant differences in the pre-Mesozoic sediments east and west of Traverse C so that Palaeozoic sediments are probably only present west of Traverse C. Perhaps the eastern limit of Palaeozoic sediments is a possible fault zone between refraction Traverses C and V_1, appearing on the reflection cross-section for Traverse V as a zone of no reflections between SP 7669 and SP 7674, with poorly matching reflections on either side of the zone.

B. RECONNAISSANCE TRAVERSES BETWEEN MARION DOWNS, HERBERT DOWNS, AND WATCHIE HUT

BMR Marion Downs No. 1 Scout Hole on Traverse A

In July 1964 a scout hole was drilled to a depth of 470 ft on Traverse A near SP 1010-2/3 to identify shallow reflection events recorded on this traverse in 1963. The first 90 ft were drilled through sand, gravel, and clay. From 90 to 360 ft the drill penetrated white and blue clay. Six-inch casing was run to a depth of 112 ft. A hard, grey limestone was entered by the drill at 360 ft below the surface and this persisted to the total depth of the hole at 470 ft. Three attempts were made to recover cores in the interval from 360 to 470 ft, but recovery was poor. On the basis of trilobite fragments found in the cores, the limestone has been correlated with the Upper Cambrian Chatsworth Limestone (M. A. Reynolds, pers. comm.).

A borehole velocity survey was carried out in the scout hole using a down-hole geophone. Recordings from the geophone were made at intervals of 25 ft down the hole from the surface to a depth of 325 ft. It was impossible to lower the geophone beyond this depth as the hole had been damaged by a bent drill pipe. The results obtained indicated that the velocity down to a depth of 75 ft was about 6750 ft/s. From 75 ft down to 325 ft a velocity of about 8450 ft/s was indicated. This velocity information proved useful in correlating reflection and refraction results on Traverse A with the borehole data.

Reflection Traverses A and Q - techniques. The section of reflection Traverse A between SP 1002 and SP 1012, including SP 1002-1/3, SP 1002-2/3, SP 1003, SP 1003-1/3, etc., to which Traverse S is linked (see Plate 2), was shot at the beginning of the 1963 portion of the survey. Since the most persistent reflections were recorded in the first few tenths of a second, short geophone spreads 600 ft in length were used to avoid interference by first-arrival refraction events with shallow reflections. Before reflection shooting commenced, a series of noise tests were made near SP 1007. The results are shown in variable-area record form in Plate 38. At the top right of Plate 45 the frequencies of recorded noise events are shown plotted against wave number. The plotted points are labelled with figures representing relative amplitudes in decibels. In the first second after the shot a number of coherent noise events were recorded, but a considerable amount of random noise was also present. The transverse spread record at the right of Plate 38 indicated that noise travelling at right angles to the traverse was not a problem.

On the section of Traverse A between SP 1002 and SP 1012 a geophone arrangement consisting of 16 geophones per trace in line parallel to the traverse was employed. This arrangement was useful in attenuating noise events with low wave number but it did introduce a large amount of ground mixing as a result of the long geophone pattern length in relation to the relatively short interval between geophone stations. As there were no indications of dipping reflections the reflection signals do not appear to have been adversely affected by the long geophone patterns. Single shot-holes drilled to a depth of 90 ft were used. The quality of reflections obtained would probably have been improved by the use of multiple-hole shot patterns.

On the section of Traverse A from SP 1001 to SP 954, shot in 1964, the spread length was increased to 900 ft to allow faster progress. Three or five-hole shot patterns drilled to 60 ft were used, the length of the shot pattern being 200 ft. The geophone arrangement consisted of 24 geophones per trace in six rows of four parallel to the traverse, the rows and individual geophones being 20 ft apart. From SP 953 to SP 856 on Traverse A a spread arrangement similar to that used on reflection Traverse V, B, and S was used. For this the spread length was increased to 1800 ft while the shot-point interval of 900 ft was retained, so that double sub-surface coverage resulted.

A series of noise tests was made near SP 927. The results are shown in variable-area record form in Plate 39 and in graphical form in Plate 45. A considerable amount of random noise was rec rded in addition to coherent noise. There was little transverse noise except in the form of long period, low velocity noise at about 1.7 seconds. The latter was of low amplitude and was readily attenuated by the shot and geophone patterns. Between SP 953 and SP 856 on Traverse A, 32 geophones per trace were used in two rows of 16 parallel to the traverse, with a spacing between geophones of $9\frac{1}{2}$ ft. The shot pattern consisted of five holes 50 ft apart drilled to a depth of 60 ft.

Traverse Q was a short reflection traverse surveyed in 1963 near Hilary Dam at the western end of Traverse A (1964) as an indicator of the reflection results to be expected between Traverse K and the portion of Traverse A then shot (in 1963). 1800-ft geophone spreads were used, with 16 geophones per trace in line at intervals of 10 ft. Shot patterns consisted of five holes 45 ft deep and 25 ft apart.

Reflection Traverses A and Q - results. On the $3\frac{1}{2}$-mile section of Traverse A between SP 1002 and SP 1012, shot in 1963, many near-horizontal events were recorded at reflection times ranging from 0.1 to 3.0 seconds (Plate 24). The most persistent reflections were recorded between 0.1 and 0.5 second. After about 0.5 second, low frequendy noise predominated over reflected energy and after about 2 seconds, high frequency wind noise was prevalent on many records as small charges were used to facilitate the recording of very shallow reflections. The deeper line-ups, after about 1.5 seconds, which do not show continuity beyond one or two records, are regarded as doubtful reflections. These are possibly caused by the considerable amount of ground mixing introduced by using a long geophone group to suppress surface noise.

Reflections recorded at less than 0.5 second, which are probably the only reliable ones, are of high frequency, but often show a lack of distinctive reflection character. It is thought that the repetitive sine-wave character observed on the early parts of many records might be due to the occurrence of a type of 'ringing' similar to that often observed in marine work, but in this case resulting from the presence of rock layers with high refraction velocities and reflection co-efficients within a few hundred feet of the surface. Increasing the depth of shot from 90 to 150 ft did not cause this effect to decrease noticeably.

The best quality reflection of the profile was recorded at about 0.27 second on the eleven records at the eastern end of the profile. It can be correlated over a distance of 1½ miles and indicates a horizon with no dip component in the direction of the traverse. Several other correlateable shallow reflections were recorded at this end of the traverse. All agree in indicating little or no dip in the direction of the traverse. Near the western end of the traverse (SP 1003 to SP 1004) a poor event was recorded at about one second on four records. It indicated an east-north-east component of dip of about 15 degrees.

It seems evident that reliable primary reflections were recorded to at least 0.3 second on Traverse A. This corresponds to a depth of at least 1300 ft, which is below the depth of the 19,000-ft/s refractor recorded on this traverse (900 ft). The 19,000-ft/s refractor is therefore unlikely to represent igneous basement. On the other hand, the reflection results on this portion of Traverse A bear little resemblance to those obtained elsewhere where it is known that there are large thicknesses of Palaeozoic sediments. Although the scout hole drilled on this traverse indicated the presence of Upper Cambrian limestone from 360 to 470 ft below the surface, it is probable that the Lower Palaeozoic sediments present are of limited thickness in this area.

On the continuation of Traverse A, to the south-west past Marion Downs and on to Hilary Dam, which was done in 1964, a single cross-section was obtained for the portion of traverse between SP 1001 and SP 954, as this was shot with single sub-surface coverage using 900-ft geophone spreads. The results of this segment of the traverse are shown in Plate 25. The portion of Traverse A between SP 953 and SP 855 was shot in a manner giving double sub-surface coverage. Plate 26 is a cross-section for this segment of traverse using only the centre 12 traces of each tape. Plate 27 is a cross-section for single coverage, using 24 traces, and Plate 28 is a cross-section for double coverage or two-fold horizontal stacking on this same segment. As on Traverses V, B, and S, the cross-section made using the centre 12 traces of each tape gave the best overall reflection quality.

As on the portion of Traverse A shot in 1963, a series of more or less horizontal reflections from about 0.1 to 0.5 second were recorded between SP 1001 and SP 979, on the continuation of Traverse A to the south-west in 1964. However, the shallower reflections (0.1 to 0.2 second), were not so continuous as they were between SP 1002 and SP 1012, mainly because of the longer geophone spread used (900 ft compared with 600 ft).

Between SP 979 and SP 890 very few reflections were recorded, apart from some poor quality shallow reflections between 0.1 and 0.2 second and some deep events mainly east of SP 961. The former were probably associated with the base of the Mesozoic sediments at a depth of a few hundred feet. The almost complete lack of pre-Mesozoic reflections between SP 961 and SP 890 suggests that this may be an area of shallow igneous basement. Gibb's interpretation of the gravity results in this area (Gibb, 1966) made before the seismic work was carried out, certainly supports this theory. In the region of SP 961 to SP 890, Traverse A crosses the south-eastern portion of the Glenormiston Gravity Low (feature 19, Plate 4).

Gibb suggests that a granite emplacement is the best explanation of the gravity 'low', the density of this being of the order of 0.1 g/cm^3 below that of adjacent, denser Precambrian metasediments as in the case of the Kalkadoon Gravity Low. The deep seismic events recorded between 1 and 4 seconds from SP 1001 to SP 961 might thus originate from Precambrian metasediments.

From SP 890 to SP 855 at the south-western end of Traverse A a number of poor to fair quality reflections were recorded between times of 0.1 and 1.0 second. These generally indicate a gentle dip to the south-west, although there are indications of a slight reversal of dip near SP 872, giving rise to a minor anticline with axis near SP 871. The lower limit of the reflections on this south-western portion of Traverse A is rather indefinite, but it would appear that conformable, gently dipping reflections are recorded up to times of at least 1.0 second in the vicinity of SP 868 to SP 862. This indicates that more or less conformable pre-Mesozoic sediments extend at least to a depth of about 6500 ft, assuming vertical velocities are similar to those measured at Canary No. 1 Bore. The age of these pre-Mesozoic sediments is unknown, but it is likely that at least the greater part of them are Proterozoic, as are the nearest pre-Mesozoic outcrops, which occur near the headwaters of Sylvester Creek, ten miles further west. If there are any Lower Palaeozoic sediments present these are likely to be relatively thin.

The reflection results obtained on Traverse Q at the western end of Traverse A towards the conclusion of the 1963 survey were poor (Plate 29). Reflections, particularly on the outer traces of each record, were badly interfered with by surface noise. Better results could no doubt have been obtained using shorter geophone spreads and longer geophone and shot-patterns. However, poor reflections were recorded up to about 0.5 second on the central traces of some records. These indicated a gentle south-westerly component of dip as on the adjoining portion of Traverse A.

Reflection Traverses N and R

Techniques. The portion of the 1964 programme designed to develop a suitable technique for making a seismic tie between the outcropping Ninmaroo Formation near Herbert Downs and Traverse A to the south-east was begun by refraction and reflection shooting on Traverse N east of Herbert Downs (Plate 2). A series of noise tests was made at SP 6105 on this traverse prior to reflection shooting. The results are shown in variable-area record form in Plate 41 and in terms of frequency, wave number, and amplitude on the relevant graph in Plate 45. In the first second after the shot instant the greater part of the noise recorded was of the coherent type and of relatively high velocity, owing no doubt to the presence of the Ninmaroo Formation, close to the surface. Little or no transverse noise was recorded.

For reflection Traverse N, 1800-ft split spreads were used, with a trace interval of 150 ft. Sixteen geophones per trace in line along the traverse were used, with a spacing of 10 ft. On the western half of the traverse, seven-hole shot patterns were drilled in a line parallel to the traverse with 23-ft spacings. Because of the

very hard drilling conditions this was reduced to a single hole on the second half of the traverse. Following tests of shot depth in a hole 200 ft deep, all shotholes were drilled to a depth of 60 ft.

The wave number cut-off point for the spatial filtering by both the shot-hole patterns and geophone patterns was 0.0031 cycles per foot. It can be seen from Plate 45 that this cut-off point was scarcely low enough to reduce some of the noise effectively, but in this case the length of the geophone patterns was limited to avoid ground mixing of the seismic traces and attenuation of possible dipping events.

Two miles of continuous reflection profiling were carried out between SP 6716 and SP 6721 on Traverse R using 1800-ft split spreads (Plate 2).

A series of noise tests was carried out near SP 6718. Plate 40 shows the results in variable-area record form. The relevant graph of frequency against wave number is shown in Plate 45. At this shot-point the strengths of the coherent and random noises were approximately equal.

The shot pattern used consisted of seven holes in line 20 ft apart or of four rows of three holes parallel to the traverse with 50 ft between holes and 30 ft between rows. The holes were 60 ft deep. Twenty four geophones per trace were used in three rows of eight with holes and rows 20 ft apart. The wave number cut-off point for the geophone pattern was 0.0021 cycles per foot. It can be seen from Plate 45 that this pattern should have been effective in attenuating most of the coherent noise. The relatively large numbers of widely spaced shotholes and geophones used should have produced a considerable reduction in the amount of random noise on the reflection records.

Results. The results of Traverse N are shown in variable-area cross-section form in Plate 30. The only events recorded were some poor quality dipping events recorded after 1.5 seconds. These events fairly consistently indicate dip to the west, but the quality is so poor that it is not clear whether they are genuine reflections, reflected refractions, or some other spurious type of event. It is clear that no reflections were recorded that could be mapped to form a tie between the Palaeozoic sediments in this area and Traverse A to the south.

Traverse R, which was shot about 15 miles south of Traverse N, was equally devoid of useful reflection results although, unlike Traverse N, it was not shot on outcropping Lower Palaeozoic rocks. The results of Traverse R are shown in Plate 31.

Refraction Traverses N, O, and R

Refraction shooting was carried out over the three-mile length of Traverse N shooting from both directions from SP 6100 and SP 6110 to measure the refraction velocity of the outcropping dolomites of the Ninmaroo Formation. The resulting time/distance graphs are shown in Plate 32 for recorded first-breaks. A more or less constant velocity of 18,500 ft/s was recorded shooting from both directions. This represented a refractor immediately beneath the weathered layer at an average of about 50 ft below the surface.

Because of the complete lack of reflection results on Traverse N, it was decided to attempt a seismic tie between the Ninmaroo Formation outcrops and Traverse A to the south using the refraction method. Consequently Traverse O was surveyed southwards from Traverse N following the Glenormiston Gravity Low (see Plate 3) and continuous refraction profiling was carried out with the object of following the refractor recorded at shallow depth on Traverse N. For this refraction profiling a geophone spread 7200 ft long consisting of 24 geophone stations 300 ft apart (600 ft at the centre) was employed. Four 4.5-c/s geophones per trace were arranged in a line perpendicular to the traverse through each geophone station, with a spacing of 22 ft between geophones. Shot-holes were usually about 60 ft deep and charges ranged from 10 to 100 lb. Shot-points were offset 3600 ft from the end of the spread and successive shot-points were normally 5400 ft apart, so that there was an overlap of 1800 ft of refractor coverage between adjacent shots on the pforile. Where the data obtained warranted it, additional shots were fired to give extra data. Fifteen miles of continuous refraction profiling were shot in this manner on Traverse O.

The results are presented in two segments in Plates 33 and 34. In these plates the travel times corrected to a datum of 500 ft above sea level are shown at the top plotted against horizontal distance. Relative intercepts for direct and reverse profiles in geophone position are plotted below the time/distance plots. These intercepts were computed relative to a single shot-point at the end of each profile assuming a constant refractor velocity for each segment of traverses. The intercept curves for direct and reverse profiles were smoothed to eliminate the effects of minor surface irregularities and meaned to give a mean relative intercept curve. Also, the divergence or non-parallelism of the direct and reverse intercept curves was used to calculate the difference between the assumed refractor velocity and the true velocity over a particular portion of the traverse. Mean delay times for the various geophone stations were computed and these were converted to depths. Depth profiles are plotted at the bottoms of Plates 33 and 34.

Refraction Traverse O indicated that it was not possible to map a single refractor with more or less constant velocity southward from Traverse N where dolomite of the Ninmaroo Formation outcrops. Where the northern end of Traverse O intersected Traverse N a refraction velocity of 17,700 ft/s was indicated. This was less than the velocity recorded on Traverse N (18,500 ft/s), which was approximately perpendicular to Traverse O. The difference in velocity is explainable in terms of anisotropy in the horizontal plane resulting from a slight dip in the beds constituting the Ninmaroo Formation. Traverse N is probably more nearly parallel to the strike of the Ninmaroo Formation than Traverse O and the refraction velocity can be expected to be higher in the strike direction where high velocity beds such as dolomites and limestones alternate with sandstones and siltstones. Along Traverse O it was found that the velocity of the high velocity refractor ranged from 16,700 to 19,250 ft/s. Refraction profiling also indicated that the surface of the high velocity material was quite irregular. It would appear, therefore, that the high velocity refractor mapped on Traverse O does not represent a uniform lithology. It is more probable that it represents a surface of unconformity, with Mesozoic sediments overlying a

succession of much older rocks, probably of the Ninmaroo Formation, or, where the high velocity refractor is very shallow, it may simply be overlain by a weathered zone of Lower Palaeozoic rocks.

It is evident from Plates 33 and 34 that the surface of the high velocity refractor remains fairly shallow over the whole length of Traverse O. It is deepest at the southern end of the traverse, but here the depth is only about 350 ft below the surface. This is about the depth at which Lower Palaeozoic limestone was encountered in BMR Marion Downs No. 1 Scout Hole on Traverse A. It is likely, therefore, that the Cambro-Ordovician succession is present at a depth of a few hundred feet all the way from Traverse O to Traverse A, but it does not appear to be possible to follow a single stratigraphical horizon within the Cambro-Ordovician by refraction profiling.

A short refraction probe was shot on Traverse R about 5 miles south-east of Traverse O. The results are similar to those obtained on Traverse O (see Plate 35). A refractor was recorded with a velocity of 19,100 ft/s and with a depth of about 400 ft. As on Traverse O the surface of the refractor appears to be uneven, with a depression centred near SP 6719.

Refraction Traverses J and K

Traverse J was surveyed to measure the velocity of the Upper Proterozoic Sun Hill Arkose where it crops out, a few miles north-east of Watchie Hut to the west of Traverse A (Plate 2). The results (Plate 46) indicate a near-surface refractor with a refraction velocity of 14,900 ft/s on the Sun Hill Arkose. A refractor with a velocity of 17,650 ft/s and a depth of a little more than 100 ft from the surface and another refractor with a velocity of 18,650 ft/s at a depth of about 400 ft were also recorded. Both these refractors indicated some south-east dip.

Traverse K was surveyed between outcrops of Upper Proterozoic Sylvester Sandstone about 5 miles east of Traverse J (Plate 2) to measure the refraction velocity of the Sylvester Sandstone. The sub-weathering velocity obtained was 14,350 ft/s (Plate 46). This was somewhat lower than would be expected if the Sylvester Sandstone was continuous between outcrops. In outcrop, this formation is silicified and very hard, and one would expect it to have a refraction velocity of at least 18,000 ft/s. However, it is possible that the silicification is only a surface effect and that under Cretaceous cover the sandstone may be much softer. A second refractor, with a velocity of 15,850 ft/s was recorded about 30 ft below the refractor with velocity of 14,350 ft/s. Both of these refractors indicate a gentle westerly dip.

It is notable that the refraction velocities recorded from sediments below the Mesozoic strata in Canary No. 1 Bore (14,200 to 17,650 ft/s), which are believed to be Upper Proterozoic, compare well with the refraction velocities recorded on Proterozoic outcrops on Traverses J and K in the Watchie Hut area.

C. TRAVERSES IN THE TOKO SYNCLINE AREA

Techniques

The reflection method proved very successful in the Toko Syncline area. Because of this, by far the greater portion of the survey effort in this area was devoted to the use of this method rather than the refraction method, which did, however, provide useful supplementary information. Prior to the commencement of reflection work in the Toko Syncline a series of noise tests was made near SP 206 in the centre of the Toko Syncline Gravity Low on Traverse F (Plate 3). As reflection Traverse F was surveyed to the south-west, two other series of noise tests were made near SP 189 and between SP 178 and SP 177, where reflections were virtually absent (Plate 47). The results of the three series of tests are shown in variable-area record form in Plates 42, 43, and 44, respectively. It should be noted that the spacing between traces for these noise tests was 10 ft, whereas the spacing for all others was 20 ft. This spacing affects the apparent degree of coherence of the noise recorded. The results are presented in graphical form in terms of frequency, wave number, and relative amplitude in Plate 45. It can be seen that the results of all three series of tests are quite similar. Coherent noise was much more predominant over random noise in each case, although there was a progressive increase in the amount of random noise recorded from SP 206 to SP 189 to SP 178. The noise test spreads near the latter shot-point were largely on a large sand dune, whereas the others were on flat areas of clayey soil. The presence of sand at the surface probably accounts for the larger amount of random noise near SP 178 and in fact it is rather surprising that the results near this shot-point were not more different from the others. In the first second after the shot instant in each of the three cases a considerable amount of relatively high velocity noise with low wave number was recorded. The choice of a linear pattern of 16 geophones with a wide spacing of about 19 ft was designed to attenuate this noise, as it provided a wave number filter cut-off of k_c = 0.0016 cycles/ft. This geophone pattern was used on most of Traverse F and on Traverse G. After it became evident that some fairly steeply dipping events were present near the south-west margin of the Toko Syncline the spacing between geophones was reduced to 10 ft (k_c = 0.0033 cycles/ft) to avoid attenuation of dipping reflections. A linear geophone pattern of 16 geophones per trace with 10-ft spacing was used on Traverses M, L, E, H, and Q (Plate 2). Where drilling progress was relatively rapid a linear shot-hole pattern consisting of seven holes at 25-ft spacing (k_c = 0.0029 cycles/ft) was employed. Elsewhere the shot pattern consisted of five holes at 25-ft spacing (k_c = 0.0040 cycles/ft). The shot-hole depth was usually 45 ft.

The split-spread method of continuous reflection profiling was used with a spread length of 1800 ft in the Toko Syncline area. However, some portions of Traverse F were also shot using 600-ft spreads, mainly to improve the quality of very shallow reflections. This procedure proved quite useful between SP 160-1/3 and SP 172 and between SP 241 and SP 248 (Plate 48). Little additional information was achieved with this technique between SP 175 and SP 180 (Plate 48).

In 1964 some common-depth-point (multiple coverage) reflection shooting was carried out on the north-east end of Traverse F with the object of eliminating multiple reflections from the lower part of the seismic cross-section. The common-depth-point shooting was done in two segments separated by an area covered by sand dunes, in which it was impossible to apply the method. The first segment, between SP 219 and SP 228 on Traverse F, was shot with the shot-point offset 300 ft from the south-western end of the spread, the furthest geophone being 7200 ft from the shot-point. A different system of shot-point numbering was adopted for the multiple coverage shooting, such that the multiple coverage shot-point number is given by

$$\text{MC No.} = 6(232 - x) + 1$$

where x is the normal shot-point number on Traverse F. The multiple coverage shot-point numbers are prefixed by 'MC' in Plate 2. Five-hole linear shot patterns were used, the holes being 25 ft apart parallel to the traverse and offset 50 ft from the traverse, with a shot-point interval of 300 ft. The geophone pattern consisted of two rows of 16 geophones in line along the traverse, the rows being spaced 20 ft apart. The spacing between geophones in each row was 10 ft.

The second segment of traverse shot with the common-depth-point method was between SP 188 and SP 212 on Traverse F. This was shot with the shot-point offset 900 ft from the north-eastern end of the spread, the furthest geophone being 7800 ft from the shot-point. A shot-point interval and geophone group interval of 300 ft was again used. The number of holes per shot-point was increased to seven with a spacing of 25 ft between holes, whilst the number of geophones per trace was reduced to a single line of sixteen per trace. The spacing between geophones was increased to 20 ft.

For both segments of multiple coverage shooting variable-area cross-sections were made with three-fold, six-fold, and twelve-fold stacking. The three-fold and six-fold stacking operations were done twice in each case, using only the twelve traces closest to the shot for each spread and also using all twenty-four traces of the spreads. The results of the common-depth-point shooting, with various types of stacking in the central playback office, are shown in Plates 51 to 60. These results will be discussed later, in the section dealing with the interpretation of the north-eastern portion of Traverse F.

Traverse F and associated traverses

As already indicated, Traverse F was surveyed as the main reflection traverse across the Toko Syncline and its associated gravity minimum (Plate 2). Reflection results obtained on Traverse F using the split-spread method are shown in corrected variable-area form in Plate 47. The cross-section shows that the reflection results were very good over a large part of Traverse F and give a definite structural picture. A very strong reflection or group of reflections can be followed continuously from SP 240, where it has a reflection time of 0.25 seconds, to SP 189, where it was recorded at 1.55 seconds. Many other reflections of generally poorer quality were recorded from both above and below this main reflection. North-west of SP 240 no reflections were recorded. South-east of SP 189 reflection quality deteriorated and correlation is more difficult, although it seems

likely that the main reflection is still present at a reflection time of 1.55 seconds at SP 180. From SP 178 to SP 176 there is an interval in which reflections are so poor as to be scarcely recognisable. Continuous events were again recorded further south-west between SP 176 and SP 169, mainly at times between 1.3 and 2.0 seconds. South-west of SP 169 only very shallow reflections were recorded.

The reflection results confirmed the presence of a large sedimentary depression whose north-east flank dips regularly to the south-west. The reflection cross-section does not define the south-west flank in the same clear manner as it does the north-east flank. However, it suggests that the structure of the depression is more complicated to the south-west and does provide some clues regarding possible structure in this area.

Identification of main reflecting horizon. Interpretation of the reflection cross-section in terms of stratigraphy depends on identification of at least one of the reflecting horizons with a known geological formation. There are no deep bores in the area, so an attempt was made to follow the main reflecting horizon, which has a maximum reflection time of 1.55 seconds, corresponding to a depth of about 10,000 ft at SP 189, to the north-east margin of the syncline, where it could be examined by shallow drilling. It was possible to follow this reflection north-east to SP 240 by using 1800-ft geophone spreads and to SP 244 by using 600-ft geophone spreads. It then proved possible to follow this horizon further to the north-east by using the refraction method.

Refraction Traverse I. This was surveyed approximately at right angles to Traverse F near its north-east end to measure the refraction velocity and the depth of the horizon that was responsible for the main reflection on Traverse F. The results indicated the presence of a refractor with a velocity of about 17,850 ft/s at a depth of about 300 ft (Plate 46). There were indications that the refractor was disturbed by minor faulting. Shallow refraction profiling was carried out along Traverse F to the north-east from SP 240 to map the depth of this refractor. The results obtained are shown in Plate 61.

The main reflection-refraction horizon does not come to the surface at the north-eastern margin of the syncline on Traverse F because of a thin cover of Mesozoic sediments, but at SP 247 near Yarrandilla yard it was indicated by refraction work to occur at a depth of about 300 ft. A test hole was drilled to 387 ft at this shot-point by means of one of the Mayhew shot-hole rigs. Hard beds, believed to correspond to the high velocity refractors recorded in the area were encountered from 330 ft onwards. A sample from a depth of about 340 ft was identified as calcareous dolomite. The sample is reported by the Geological Branch of the BMR to have contained several conodonts which, if not derived, are typical of the Lower Ordovician Ninmaroo Formation. It is not surprising that the Ninmaroo Formation should approach the surface here since it crops out about thirty miles to the north-west, along strike from the Yarrandilla area. There is thus some reliable evidence that the main reflection on Traverse F comes from the Ninmaroo Formation. For ease of reference this reflection will be referred to as the 'Ninmaroo reflection'.

The most pronounced reflection above the 'Ninmaroo reflection' is recorded at about 1.0 second at SP 189 on Traverse F. It can be followed to the north-east to about SP 221, where it was recorded at about 0.3 second. On the basis of strike trends in the Toko Syncline outcrop area to the north-west, and considering its relation to the 'Ninmaroo reflection', it seems probable that this persistent shallower reflection represents a horizon somewhere near the top of the Toko Group.

Vertical velocity information. Apart from the identification of at least one of the more important reflecting horizons, the other main requirement for the interpretation of the seismic results obtained in the Toko Syncline is a knowledge of vertical velocities which will allow conversion of recorded reflection and refraction times to depth in feet. To obtain such knowledge, t:Δt analyses were made on all the major reflection traverses. In addition, five special velocity profiles were shot at intervals along Traverse F and perpendicular to it using the method of Musgrave (1962). It is convenient to consider the velocity results obtained before discussing in detail the seismic results obtained and their interpretation.

Because of the considerable length of Traverse F and the possibility of horizontal velocity variation along it, t:Δt plots were first made separately for each of four segments of the traverse and the results compared. These plots showed only slight differences. Also, t:Δt values for a single prominent reflection were plotted for the segment of Traverse F between SP 229 and SP 239, where the reflecting horizon dips appreciably. Again the results obtained were not very different from those obtained by plotting all reflections on Traverse F. It may be concluded that horizontal variation in vertical velocity distribution across the Toko Syncline is small. Average t:Δt curves were constructed for the portion of the survey in the Toko Syncline for 1800-ft and 600-ft spreads (Plate 74). These curves were used for the application of dynamic corrections to the majority of reflection cross-sections in the area. For reflection times from zero to about 0.3 second, Δt values on the curves were calculated assuming a weathered layer with a velocity of 2500 ft/s and a sub-weathering layer with an average vertical velocity of 5750 ft/s extending to a depth of several hundred feet. Weathering spreads, first-break plots and uphole times indicated that these conditions apply on the southern half of Traverse F, where the best quality shallow reflections were obtained. Δt values from 0.3 to 0.7 second were largely derived from records shot with 600-ft spreads on Traverses E and F, while values from 0.7 to 2.0 seconds were derived from 1800-ft spreads. Beyond 2.0 seconds, observed Δt values were unreliable and the remainder of the t:Δt curve was calculated assuming a constant velocity of 18,500 ft/s.

The average t:Δt curve of Plate 62 was used for the application of dynamic corrections to the record cross-sections for Traverse F (SP 161 to SP 251, 1800-ft spreads) and for Traverses E, M, L, and G. For multiple coverage work and collinear offset shots on Traverse F, where dynamic correlations were large and important, slightly different velocity distributions were used for computing move-out. In calculating these, greater emphasis was placed on the results of velocity profiles and t:Δt data in the immediate vicinity

of the reflection work in question. For several short segments of traverse shot with 600-ft spreads near the ends of Traverse F the dynamic corrections applied also varied slightly from the average t:Δt curve, as they were based on more local reflection results.

The locations of Velocity Profiles E, U, W, T, and H are shown in Plate 2 and the resulting variable-area record cross-sections are shown in Plates 63 to 67, respectively. The computed velocity results are shown in the form of $T^2:X^2$ graphs in Plates 68 to 72, respectively, and are summarised below in Tables 3 to 7. The average velocities computed from each of the velocity profiles and also from the average t:Δt curve of Plate 62 are shown plotted together in Plate 73 for comparison. It can be seen that there is reasonably good agreement between velocities derived from the velocity profiles and from the average t:Δt curve for reflection times up to 2 seconds. Some of the individual values for the velocity profiles would appear to be doubtful and hence it is advisable as well as convenient to use the average velocities derived from the t:Δt analysis for conversion of time to depth in general.

Results on Traverse F. First-break refraction times for the reflection shots on Traverse F indicate that there is a thin veneer of Mesozoic sediments, with a velocity of about 6000 ft/s, at the surface overlying material with velocities of 10,000 to 14,000 ft/s, which are considered too high for the Mesozoic in this area. The thickness of the Mesozoic sediments ranges from about 150 ft to about 4000 ft and probably averages about 250 ft along Traverse F. On the noise test spreads shot on Traverse F, where the geophone station interval was only 10 ft, a reflection was recorded at about 0.1 second on the records nearest the shot, which was probably associated with the marked velocity discontinuity at the base of the Mesozoic.

TABLE 3

Results of velocity profile on Traverse E

Intercept time (seconds from $T^2:X^2$ plot)	Interval reflection time (seconds)	Apparent average velocity (ft/s)	Interval velocity (ft/s)	Depth (ft)	Average velocity (ft/s)
	0.800		12,150		
0.800		12,150		4,860	12,150
	0.164		7,570		
0.964		11,500		5,480	11,370
	0.138		13,750		
1.102		11,800		6,430	11,670
	0.447		17,260		
1.549 (Ninmaroo reflection)		13,600		10,288	13,270

Intercept time (seconds from $T^2:X^2$ plot)	Interval reflection time (seconds)	Apparent average velocity (ft/s)	Interval velocity (ft/s)	Depth (ft)	Average velocity (ft/s)
	0.150				
1.699 *	(0.261)	12,650	(18,180)		
	0.111				
1.810		14,350		(12,660)	(13,990)
	0.111				
1.921 *	(0.334)	13,550	(14,030)		
	0.223				
2.144		14,300		(15,003)	(13,995)

TABLE 4

Results of velocity profile on Traverse U

Intercept time (seconds from $T^2:X^2$ plot)	Interval reflection time (seconds)	Apparent average velocity (ft/s)	Interval velocity (ft/s)	Depth (ft)	Average velocity (ft/s)
	0.707		11,300		
0.707		11,300		3,995	11,300
1.265 *	(0.773)	11,150	(14,370)		
1.480		13,000		9,549	12,900
	0.140		13,000		
1.620		13,000		10,459	12,910
	0.407		17,020		
2.027		13,900		13,922	13,740

* Apparent average velocities for these events suggest that they are probably multiples. The figures in brackets represent values obtained ignoring these events.

TABLE 5

Results of velocity profile on Traverse W

Intercept time (seconds from $T^2:X^2$ plot)	Interval reflection time (seconds)	Apparent average velocity (ft/s)	Interval velocity (ft/s)	Depth (ft)	Average velocity (ft/s)
	0.572		8,800		
0.572		8,800		2,517	8,800
	0.129		15,890		
0.701		10,470		3,550	10,130
	0.404		13,500		
1.105		11,670		6,277	11,360
	0.135		14,450		
1.240		12,000		7,260	11,710
	0.200		20,010		
1.440		13,400		9,261	12,860
	0.209		24,660		
1.649		15,300		11,850	14,380
	0.131				
1.780 *	(0.423)	11,320	(15,880)		
	0.292				
2.072		15,410		15,209	14,680
	0.868		24,840		
2.940		18,700		25,990	17,680

TABLE 6

Results of velocity profile on Traverse T

Intercept time (seconds from $T^2:X^2$ plot)	Interval reflection time (seconds)	Apparent average velocity (ft/s)	Interval velocity (ft/s)	Depth (ft)	Average velocity (ft/s)
	0.765		11,250		
0.765		11,250?		4,303	11,250?
	0.068		4,104		
0.833		10,850		4,443	10,667

Intercept time (seconds from $T^2:X^2$ plot)	Interval reflection time (seconds)	Apparent average velocity (ft/s)	Interval velocity (ft/s)	Depth (ft)	Average velocity (ft/s)
	0.101		19,000		
0.934		12,000		5,403	11,560
	0.102		6,028		
1.036		11,550		5,710	11,023
	0.671				
1.707 *		11,250			

TABLE 7

Results of velocity profile on Traverse H

Intercept time (seconds from $T^2:X^2$ plot)	Interval reflection time (seconds)	Apparent average velocity (ft/s)	Interval velocity (ft/s)	Depth (ft)	Average velocity (ft/s)
	0.687		11,000		
0.687		11,000		3,778	11,000
	0.047		13,800		
0.734		11,200		4,102	11,180
	0.072		10,630		
0.806		11,150		4,484	11,120
	0.060		22,270		
0.866		12,250		5,152	11,900
	0.143		14,540		
1.009		12,600		6,190	12,280
	0.409				
1.418 *		10,800			
	0.118				
1.536 *		10,700			
	0.099				
1.635 *		11,750			

* Apparent average velocities for these events suggest that they are probably multiples.

Reflections from below the Mesozoic and down to the 'Ninmaroo reflection' indicate conformable sediments extending from the north-eastern margin of the syncline at least as far as SP 189 (Plate 47). The thicknesses of individual beds in this conformable sequence increase only slightly from the north-eastern margin of the syncline towards its deepest part, the reflections in this zone being practically parallel to each other.

In the deepest part of the syncline on Traverse F, this sequence of pre-Mesozoic sediments above the 'Ninmaroo reflection' has a thickness of about 10,000 ft. It is quite possible that the 'Ninmaroo reflection' is associated with a horizon near the top of the Ninmaroo Formation, so that there may be up to about 2000 ft of Ninmaroo Formation below the 'Ninmaroo reflection' horizon. As the combined maximum thickness of Cambro-Ordovician sediments of the Ninmaroo Formation and Toko Group known in outcrop is only about 5000 ft, there remains on Traverse F at least 5000 ft of sediments whose age is uncertain. It is quite possible that the Ninmaroo Formation and Toko Group are thicker in the vicinity of Traverse F than they are in the Toko Range outcrop area to the north-west, but nevertheless it seems probable that post-Ordovician and pre-Mesozoic sediments are present on Traverse F, especially as coelolepid fish-scales of Upper Silurian-Lower Devonian age have been reported by P. J. Jones in samples from shot-holes in the Toko Range (Reynolds & Pritchard, 1964, Appendix 4).

Interpretation of the seismic cross-section below the 'Ninmaroo reflection' is complicated by the possible existence of multiple reflections, the presence of which is made likely by the very high reflection coefficient shown by the 'Ninmaroo reflection' horizon and perhaps other reflecting horizons over a large interval of Traverse F. Between SP 231 and SP 221 there is a definite dipping event, occurring at reflection times of about 1.25 and 1.8 seconds at SP 231 and SP 221, respectively, which has the appearance of being a simple multiple of the 'Ninmaroo reflection'. The deeper event occurs at approximately twice the time of the 'Ninmaroo reflection' and has twice its dip, as would be expected if it were a multiple. Velocity Profiles T and H confirm that this event is in fact a multiple. It was recorded at a centre time of 1.71 seconds on Profile T (Table 6) and it indicated a lower average vertical velocity than events from much shallower depths. Similarly, it was recorded at a centre time of 1.54 seconds on Profile H and indicated an average vertical velocity no greater than events at half this time.

Tables 3 to 7 indicate the probable existence of a number of other multiples, although it must be pointed out that events marked by asterisks on these tables may not all be multiples. Because of the ambiguities involved in picking some of the poorer quality events on the velocity profiles the average velocities calculated for these events can be somewhat erroneous. Similarly, some of the events not labelled as possible multiples may in fact be multiples.

Use of the common-depth-point method on two sections of Traverse F, between SP 219 and SP 228 and between SP 188 and SP 212, was directed towards the elimination of multiple reflections from the deeper parts of the seismic cross-section in the hope that a clearer picture of pre-Palaeozoic reflections might result. Referring to the stacked cross-sections in Plates 51 to 60, it is seen that for

three-fold and six-fold coverage, slightly better reflection results were obtained where only the 12 traces closest to the shot were used in stacking rather than all 24 traces. The probable explanation for this is seen in Plates 66 and 67, the cross-sections for the velocity profiles on Traverses T and H. These cross-sections show that reflections from about 0.8 second onwards suffer considerably more interference from noise emanating from the shot at distances in excess of about 3600 ft from the shot-point.

It is evident from the multiple coverage cross-sections that there is a slight improvement in reflection quality from three-fold stacking to six-fold stacking and from six-fold stacking to twelve-fold stacking. Comparing the cross-sections for twelve-fold stacking with that for single coverage with the split-spread method (Plate 47) it is evident that the multiples in the lower part of the section have been considerably attenuated by common-depth-point stacking. As a result, events below 2.0 seconds with dips different from those of the multiples stand out more clearly on the multiple coverage cross-sections (Plates 59 and 60).

It appears that common-depth-point shooting has also resulted in the attenuation of some reflections, particularly the shallower ones. This is no doubt because the geophone patterns were too long to record shallow reflections effectively at long offset distances where the emergent reflected rays had considerable horizontal components. For the common-depth-point shooting between SP 188 and SP 212 a linear pattern of 16 geophones with 20-ft spacing was used. This provided a spatial filter in the horizontal direction with a wave number cut-off at 0.0016 cycles per foot. At a distance of 5000 ft from the shot a reflection at 0.5 second with a frequency of 30 cycles per second would have a horizontally travelling component with a wave number of at least 0.0030 cycles per foot. This would be considerably attenuated by the geophone pattern. Spacing the geophones at 10 ft or less would probably have improved the shallower reflections, but as the common-depth-point method was employed to improve the later events that were not multiples, use of the wider geophone spacing was justified.

Despite the undoubted occurrence of multiple reflections on Traverse F, the evidence both of the velocity profiles and of the reflection cross-sections clearly indicates that some primary reflections indicative of sediments were recorded from below the 'Ninmaroo reflection'. On the reflection cross-section (Plate 47) between SP 188 and SP 228 there is a band of strong, correlateable events extending to about 0.5 second below the very strong 'Ninmaroo reflection'. These events remain practically parallel to the 'Ninmaroo reflection' and earlier reflections, even when the latter indicate a considerable dip, and for this reason they are unlikely to be simple multiples of shallower reflecting horizons. This view is supported by the results of Velocity Profiles E, U, W, T, and H, which indicate that events at times of 2.14, 2.03, 1.65, 1.04, and 1.01 seconds, respectively, all of which are in this band of reflections below the 'Ninmaroo reflection', have average velocities which suggest they are primary reflections. The width of this group of reflections increases slightly from the north-east towards the deepest part of the syncline, where they probably represent 4000 to 5000 ft of sediments. Some or all of these sediments might belong to

the Ninmaroo Formation of Upper Cambrian to Middle Ordovician age, but it is probable that Middle Cambrian sediments are also included, because sediments of this age are known in outcrop to the north-east of the Toko Syncline and elsewhere in the Georgina Basin.

Events below this group on Traverse F are generally poorer in quality, with some exceptions, and interpretation of the deeper parts of the cross-section must necessarily be doubtful. Between SP 191 and SP 212, a number of poor to fair events was recorded after reflection times of 2.2 and 1.7 seconds, respectively; these indicate south-west dips, slightly but significantly steeper than the events above them which are conformable with the 'Ninmaroo reflection'. The results of Traverse G, surveyed at right angles to the north-east end of Traverse F through SP 202, indicate that they have little or no dip component perpendicular to Traverse F (Plate 80). The steeper events when followed towards the north-east often appear to be truncated by shallower, less steeply dipping events. Between SP 195 and SP 200 the slightly steeper events were recorded from about 2.0 seconds to beyond 3.0 seconds, and over this time interval they exhibit a degree of parallelism with one another. This parallelism in dipping events suggests that the events are not simple multiples arising from secondary reflection from the surface of the ground, but they could still be inter-bed multiples whose reflection paths are partly backwards and forwards between two or more parallel beds. The cross-section for this portion of Traverse F using twelve-fold multiple coverage (Plate 60) shows that although the events in this group were somewhat attenuated by the multiple coverage they remain quite strong at about 3 seconds in the vicinity of SP 200 (MC 193). On the evidence available it is not possible to say whether these events are primary reflections or multiples. If they are genuine reflections from sediments, the fact that they are unconformable with the 'Ninmaroo reflection' strongly suggests that the sediments would be Proterozoic in age rather than Lower Palaeozoic.

On the north-eastern half of Traverse F many poor quality events were recorded from below the band of reflections following the 'Ninmaroo reflection'. Most of these indicate dips to the south-west and the apparent dip angles of these events tend to increase with depth. It is considered that many, if not most, of these events are multiple reflections. Others, particularly the events which do not indicate south-west dip, may be genuine reflections from deep sediments. A prominent event in this category can be seen on one of the multiple coverage cross-sections (Plate 60) at a time of about 2.1 seconds in the vicinity of SP 210 (MC 133). This event indicates a gentle dip to the north-east along Traverse F. The velocity profile on Traverse W (Plate 65), which was surveyed perpendicular to Traverse F through SP 212, indicates that the 'Ninmaroo reflection' horizon and reflection horizons conformable with it down to about 1.8 seconds have little or no dip component along Traverse W. It would therefore be expected that multiples associated with these horizons would also have little apparent dip along Traverve W. Now below about 2 seconds on the cross-section for Traverse W there are a number of events which indicate moderately steep dips to the north-west. These appear on the cross-section as 'washboard' patterns of alternating left and right dips owing to the fact that the order of traces is reversed on every alternate record of the velocity profile (Musgrave, 1962). It seems likely that these dipping events on Traverse W correspond to the events indicating slight north-east dips on Traverse F. The recorded

times agree, although this in itself is not sufficient criterion for establishing the connection since on Traverse F events indicating south-west dip and those indicating gentle north-east dip are frequently superimposed and interfered with by each other. The deep events indicating north-west dip along Traverse W and little dip component along Traverse F most likely represent Proterozoic sediments.

An important group of dipping events was recorded on Traverse F between SP 190 and SP 205 after record times of about 3.1 and 3.9 seconds, respectively. These events are very conspicuous on the record cross-sections (Plates 47 and 60), particularly as they indicate moderately strong dips to the north-east, in contrast to the events above them, which mostly indicate dips to the south-west. Another less conspicuous exception to this general rule of south-west-dipping events is seen on the multiple coverage cross-section (Plate 60) at about 2.8 seconds beneath shot-points MC 205 to MC 215 where an event indicates north-east dip similar to that of the large group below. The north-east component of dip of these events along Traverse F virtually rules out the possibility that they are multiples. The absence of any appreciable curvature makes it unlikely that they are diffractions. The possibilities remain that they may be reflected refractions or genuine reflections. With such a strong refractor as that associated with the 'Ninmaroo reflection' in the sedimentary section (see Refraction Traverse E) the former possibility must be considered.

Now the apparent velocity of these events along Traverse F is about 35,000 ft/s. Assuming that they are reflected refractions which have been refracted along the 'Ninmaroo' horizon with a refraction velocity of 20,000 ft/s and that this refractor is more or less horizontal, then the plane reflecting these refractions, which must be more or less vertical, must make an angle θ with the traverse so that $\sin \theta = \frac{20,000}{2 \times 35,000}$. The angle θ indicated is only about 16 degrees, or less if one takes into account the south-west dip of the refractor and assumes that the reflecting plane intersects the traverse south-west of the shot-point considered. The angle will be still smaller if a refractor with a velocity of less than 20,000 ft/s is involved. This means that for traverses such as Traverse G and Traverse U, surveyed perpendicular to Traverse F, the supposed reflecting plane would be approximately perpendicular to the traverse and the apparent velocity of reflected refractions recorded on these traverses would be less than 11,000 ft/s. In fact no events with such low apparent velocities were recorded at the expected times on Traverses G and U. At SP 202 on Traverse F, through which Traverse G was surveyed, the events with a north-easterly component of dip were recorded strongly from about 3.7 seconds. On Traverse G, events indicating a south-easterly component of dip and with an apparent velocity of about 55,000 ft/s were recorded at the same time. These are considered to be the same events. Similarly, on the velocity profile of Traverse U, events indicating a south-easterly component of dip were recorded around 3.3 seconds, the same time as the north-easterly-dipping events were recorded strongly on Traverse F in the same area. The quality of the dipping events is poor on Traverse U and their apparent velocity is difficult to measure accurately, but it is certainly in excess of 30,000 ft/s.

It seems fairly certain, therefore, that the group of deep events between SP 190 and SP 205 on Traverse F, which indicate a north-easterly component of dip, are not reflected refractions but genuine reflections. Taking into account the equivalents of these reflections on Traverse G it may be concluded that they probably represent metamorphic or igneous rocks whose true direction of dip is east-north-east. Such an interpretation is not inconsistent with the gravity profile on Traverse F, as will be pointed out in a later section.

South-west of SP 189 on Traverse F the quality of reflections is generally poorer than to the north-east and in places it is difficult to correlate even the strongest reflections. It seems fairly certain that the 'Ninmaroo reflection' and the group of reflections following it for about 0.5 second were recorded from SP 189 to SP 178, although the reflection quality is so poor on some records that the continuous correlation is not possible for the whole of this segment of traverse. The 'Ninmaroo' group of reflections exhibits a change in reflection character between SP 189 and SP 185, but, although reflection quality is poor, some near-horizontal events appear to be continuous between these two shot-points. Reflection quality was particularly bad near SP 182 and SP 183. Collinear offset shots were tried here in an attempt to improve results, with the geophone spreads from 1800 to 5400 ft from the shot. Improvement was slight, but the results obtained (Plate 49) tended to confirm that the 'Ninmaroo reflection' was still present in this area. Reflection quality at SP 180 was quite good. The character of the 'Ninmaroo' group of reflections was quite similar to that recorded at SP 185 and some shallower reflections recorded at SP 180 also appear to correlate with reflections at similar times recorded at SP 190. It is therefore concluded that the Palaeozoic sediments are more or less horizontal between SP 190 and SP 180, although subject to minor undulations and possible facies changes and perhaps disturbed by minor faulting, which might account for poor reflection continuity in places. The reflections indicate the presence of a small anticline between SP 189 and SP 185 with axis near SP 187 and an amplitude of up to 250 ft.

Between SP 178 and SP 176, results obtained using 1800-ft split spreads were extremely poor, no definitely recognisable reflections being obtained. The portion of Traverse F between SP 180 and SP 175 was also shot using 600-ft split spreads and 16 geophones per trace in line at 20-ft intervals. Results between SP 176 and SP 178 were still very poor (Plate 48). It was considered that the poor results in this area were at least partly due to the surface conditions, as the traverse crossed a large sand dune centred close to SP 177. For this reason some collinear offset reflection shots were tried, in which the shots were placed beyond the dune on one side and the geophones beyond the dune on the other side in such a way as to record from the sub-surface between SP 176 and SP 178. The results are shown in Plate 50. In this case the collinear offset shots showed a noticeable improvement, at least to the point where the records obtained suggested that the reflections recorded at SP 178 between 1.6 and 2.2 seconds may continue south-west to SP 176. However, reflection quality was still very poor and the existence of these reflections between SP 178 and SP 176 is still doubtful.

Between SP 171 and SP 176, a strong band of events was recorded between 1.4 and 1.9 seconds. These events indicate a gentle south-west dip south-west of SP 173 and an increasingly strong north-east dip north-east of SP 173. Interpretation of these events presents several problems. It must be decided whether they correspond to the 'Ninmaroo' group of reflections recorded at about the same times at SP 180 and further north-east, whether the dipping events north-east of SP 173 are reflections or diffractions, and what is the nature of the structure indicated at the south-western ends of these events. In answering these questions it is necessary to take into account the seismic reflection results on Traverse L surveyed more or less parallel to Traverse F a few miles to the north-west (Plate 2) as well as other seismic data and the gravity profiles on Traverses F and L (Plate 83).

Although it is certainly not possible to correlate any event continuously between SP 173 and SP 180, it is considered that the prominent groups of reflections recorded at each of these shot-points at about 1.5 seconds represent the same stratigraphic horizons. Assuming there is a reflection time difference of about 130 milliseconds between corresponding reflections, the two groups of reflections show a high degree of correlation in reflection frequency, relative amplitude from cycle to cycle, and in the total number of reflection cycles comprising the groups. Correlation of the groups on the basis of reflection character is better between SP 173 and SP 180 than it is between SP 180 and SP 190, although the actual reflection times are much closer in the latter case.

The prominent dipping events from about 1.5 to 2.0 seconds recorded between SP 173 and SP 176 could conceivably be diffractions arising from discontinuities produced by a fault in the vicinity of SP 173. In fact the amount of dip indicated by these events agrees well with that calculated for hypothetical diffractions originating beneath SP 173. However, the dipping events show practically no decrease in amplitude from SP 173 to SP 176, where they appear to terminate abruptly. This is a feature not characteristic of diffraction patterns. There is some weak evidence that the dipping events may be present further to the north-east. For example, there were some faint north-east-dipping events recorded near SP 179 and SP 180 below 2 seconds, but these are considered too doubtful to be taken as evidence of continuing diffractions. It should be noted, too, that the strong events recorded between SP 171 and SP 173 from about 1.4 seconds onwards give rise to multiples at about 2.8 seconds, or twice the reflection time. Now these multiples appear to continue to the north-east between SP 173 and SP 176, in the form of events which indicate steeper north-east dip than the strong events in question at about half their reflection times. But since diffractions are unlikely to be followed by related multiples, it seems very likely that the strong, dipping events between 1.6 and 2.0 seconds in the vicinity of SP 175 are actually reflections which give rise to multiples, as they do elsewhere on Traverse F.

The character of the north-east dipping events on the corresponding portion of Traverse L to the north appears to support this conclusion (Plate 78). On Traverse L the dip indicated is not so steep as on Traverse F and there is little indication of any curved

events which might be diffractions. However, diffraction patterns without appreciable curvatures can be produced when the seismic traverse is not perpendicular to the strike of the diffracting features.

If it is fairly certain that the strong events recorded between SP 171 and SP 176 represent reflections of some sort, it is less certain what type of structure they indicate. The degree of curvature of these events is close to that of a surface of maximum convexity (Hagedoorn, 1954). Upon migration, the events tend to be concentrated in the vicinity of points beneath SP 173, as would be the case for a diffraction pattern. A simple anticlinal or monoclinal structure similar in cross-section to the reflection profile is therefore not indicated.

South-west of SP 173 the strong group of reflections recorded from about 1.4 seconds onwards show some other peculiar features. The shallowest of these reflections terminates fairly abruptly between SP 171 and SP 172. Deeper events terminate successively further to the south-west, the deepest reflection in the group terminating beneath SP 169 at a reflection time of about 1.8 seconds. These facts suggest that the reflections are cut off by a fault plane dipping at a comparatively low angle to the south-west. Now between SP 169 and SP 174 a straight, south-westerly dipping event was recorded at about 1.4 and 1.0 seconds, respectively, which does not appear to be conformable with the deeper reflections. It is considered that this event could be associated with a fault plane dipping at a low angle to the south-west. Such low-angle faults, if the phenomena do in fact originate from faults, would of necessity be reverse faults rather than normal faults. It is proposed to postpone final discussion of the events near SP 169 to SP 176 on Traverse F until after the section of the Report dealing with comparison of seismic and gravity results.

South-west of SP 169 no correlateable events were recorded on Traverse F except reflections from very shallow depths, with reflection times of up to about 0.3 second. The portion of Traverse F from SP 161 to SP 172 was re-shot using 600-ft split spreads to improve the continuity of these very shallow events. It can be seen from Plate 48 that the quality of the shallow reflections was considerably improved. At the south-western end of Traverse F, between SP 160-1/3 and SP 165, an event at 0.2 second indicated little or no dip. From SP 165 to about SP 168-2/3, north-east dip was indicated by this reflection, the recorded time increasing from 0.2 to 0.3 second. Between SP 168-2/3 and SP 169, this reflection terminates abruptly and a probable fault is indicated. Between SP 169 and SP 172 a reflection indicating little dip was recorded at about 0.2 second. Since only one strong, shallow reflection was recorded on either side of the probable fault it seems logical to correlate the two across the discontinuity. It is most likely that the reflection is associated with a velocity change at the base of the Mesozoic. If this is so and correlation across the probable fault is valid, then a fault throw of about 300 ft, with the downthrow side to the south-west, is indicated near SP 169.

Shallow refraction profiling, SP 171 to SP 178, Traverse F. Because of the difficulty of interpreting the reflection results near the south-western end of Traverse F the refraction method was considered as a possible means of obtaining additional information. The area near SP 173 was considered to be structurally too complex for refraction techniques to be applied to deep refractors. However, it was observed that there were some notable changes in near-surface refraction velocities in this area, which might provide indications of structure. Consequently a continuous profile designed to record shallow refractors was shot from both directions between SP 171 and SP 178. The shot-to-geophone distances ranged from 1800 to 5400 ft for each refraction shot, so that using the first-break recordings from the 1800-ft split-spread reflection shots on this traverse as well, refraction times were recorded at distances from zero to 5400 ft shooting from both directions. The interval between geophone stations was 150 ft. The resulting time/distance graphs and interpretation are shown in Plate 62. Because of the relatively shallow depths of the refractors involved the times plotted are uncorrected times and the refractor depths are shown relative to surface.

Over the whole of the refraction profile, sub-weathering refraction velocities of about 6500 ft/s were recorded. Intercept times for this refractor ranged from 6 to 13 milliseconds. Assuming a weathered layer velocity of 1200 ft/s, weathered layer thicknesses ranging from 7 to 16 ft are indicated. The comparatively low sub-weathering velocities recorded suggest that the shallower sediments are Mesozoic. For the purpose of calculating the depth to the beds beneath the Mesozoic it was assumed that the average vertical velocity of the Mesozoic sediments was 6000 ft/s. To supplement the refraction information, holes were drilled to the first hard rock layer near shot-points 173, 174, and 176, and the refraction results have been tied in to the drilling results.

The refraction work confirmed that this is a tectonically disturbed area. Because of this, detailed refraction interpretation is difficult, but some useful conclusions can be drawn. On the basis of apparent velocity recorded, the segment of traverse between SP 171 and SP 178 can be divided into three parts, which are apparently separated by two faults.

North-east of SP 175, the apparent velocities recorded from below the 6000 ft/s layer were about 11,900 ft/s. Shooting from the north-east the apparent velocities were slightly higher than those obtained shooting from the south-west. A slight component of dip of about 0.3 degree to the north-east is therefore indicated for the deeper layer. Taking into account the depth of the shots and the increased time in the weathered layer, depths calculated from intercept times at shot-points 175, 176, and 177 were 355, 320, and 325 ft, respectively. These figures indicate that the 11,900 ft/s refractor corresponds to hard graphitic claystone encountered at 345 ft in a drill hole at SP 176 below several hundred feet of soft black clay.

South-west along the profile, a marked increase in apparent velocity recorded from below the 6000-ft/s layer is observed a short distance to the north-east of SP 175, and another increase is observed between SP 173 and SP 174. On the central portion of the

profile between these two velocity discontinuities, apparent velocities averaging about 15,700 ft/s were recorded when shooting from the south-west, and velocities averaging 18,150 ft/s were recorded when shooting from the north-east. These apparent velocities indicate a refractor with true velocity of 16,850 ft/s with a dip component of about 1.6 degrees to the north-east. The depths calculated for this refractor from intercept times at SP 173 and SP 175 were 185 and 325 ft respectively. These depths are consistent with the fact that the 16,850-ft/s refractor corresponds to the hard rock encountered by the drill at SP 174 at a depth of 257 ft after drilling through black clay.

The change in velocity of the sub-Mesozoic layer about 200 ft north-east of SP 175 from 11,900 ft/s to 16,850 ft/s is evidently due to the presence of a fault. The large differences in velocity, nearly 5000 ft/s, suggests that the fault is an important one. On the assumption that younger sediments generally exhibit lower velocities than older sediments, it seems likely that the downthrow side of the fault is to be north-east, but the refraction work provides no indication of the dip of the fault plane. This has been shown as being vertical in Plate 62, but in fact it could be a reverse fault with a fault plane far from vertical.

Another refraction discontinuity was observed about 500 ft north-east of SP 173. In this case the difference in velocities is not so great, but there does appear to be a marked change in dip. On the south-western portion of the traverse apparent velocities of about 24,350 ft/s were recorded when shooting from the south-west and apparent velocities of 15,300 ft/s were recorded from the north-east. This indicates a refractor with a true velocity of 18,750 ft/s with a dip of $4\frac{1}{2}$ degrees to the south-west. As on the other portions of this refraction profile the depths calculated from intercept times indicate that the high velocity refractor corresponds to the first hard layer encountered by the drill, in this case a siliceous sandstone entered at a depth of 230 ft in a hole drilled 150 ft south-west of SP 173. Depths calculated from intercept times at shot-points 174, 172, and 171 were 180, 380, and 475 ft, respectively. It is possible that the velocity change about 500 ft north-east of SP 173 indicates the presence of a fault, although a change in sub-Mesozoic velocity from 16,850 ft/s to 18,750 ft/s could possibly be explained by a horizontal facies change.

Unfortunately the age of the siliceous sandstone from the hole near SP 173 is unknown. A sample was examined by BMR geologists, who thought that its appearance suggested it might be Lower Palaeozoic or older. However, its age could be anything from Proterozoic to Devonian.

Refraction Traverse P. Some refraction shots were fired on Traverse P near the south-western end of Traverse F in the hope that they might produce evidence to account for the complete lack of deep reflections on this portion of Traverse F. The results are shown in Plate 46. A refractor with a velocity of 18,300 ft/s was recorded at a depth ranging from about 550 ft to 800 ft below the surface. This refractor showed a considerable dip towards the south-east. It was considered that this refractor might represent metamorphic or granitic basement, since the velocity is of the right

magnitude and this would explain the lack of reflections. Also, in the Lake Wickamunna area to the south-east several water bores encountered granite after penetrating about 1500 ft of Mesozoic sediments. Because of the south-east dip of the refractor it was considered that it might be easy to test this theory by drilling a hole to the north-west of Traverse P, where the refractor might be quite shallow. A hole was drilled to a depth of 500 ft near Ethabooka Springs, 15 miles north-west of Traverse P, in the hope of determining what lay beneath the Mesozoic cover, but the hole bottomed in marine Lower Cretaceous clay.

Reflection Traverse M

Because of the doubtful quality of reflections on Traverse F near SP 177 and SP 183 it was decided to survey Traverse L across the south-western margin of the Toko Syncline more or less parallel to Traverse F and a few miles north of it, where there were no sand dunes. Traverse L was linked to Traverse F by Traverse M at one end and portion of Traverse E at the other end, so that a closed loop was formed (Plate 2). Traverse M was surveyed roughly along strike and approximately at right angles to Traverse F through SP 172.

The reflections recorded at about 1.5 and 1.7 seconds at SP 172 on Traverses F were recorded along most of Traverse M with little change in depth (Plate 77). The reflections were unpickable between SP 2998 and SP 2999, probably owing to the effects of a minor fault, downthrown to the south. Over most of Traverse M, the reflections indicate a very slight dip to the south-east, but at the north-western end there is an indication of north-westerly dip on one record.

Reflection Traverse L

Results on this traverse show a number of similarities to those on Traverse F, which is roughly parallel to it, but in general the reflection quality is a little poorer on Traverse L (Plate 78). The main group of reflections recorded from about 1.4 seconds onwards on Traverse M is clearly recognisable on Traverse L near the north-western end of Traverse M. These reflections can be correlated continuously from SP 3098 to SP 3102 and possibly to SP 3103. A north-easterly dip is indicated over this interval. The reflections appear to terminate quite definitely between SP 3098 and SP 3097 near the south-western end of the traverse, probably owing to a fault. It is noteworthy that between SP 3098 and SP 3100 an event indicating south-west dip was recorded at about 1.0 second and 0.8 second respectively, which probably corresponds to the similar event recorded between SP 169 and SP 174 on Traverse F, which is considered to be related to a reverse fault. South-west of SP 3103, deep events were recorded down to about 4.5 seconds. Some of these, particularly those around 3 seconds reflection time, may be multiples of the main group of reflections, but there are others that are probably not multiples. Some of these, such as those recorded at about 3.8 seconds at SP 3098, indicate fairly strong dips to the north-east.

Between SP 3102 and SP 3112, reflection quality was very poor, except for some very deep events from about 4 seconds onwards. This portion of Traverse L evidently corresponds to the

portion of Traverse F between SP 176 and about SP 186. Near SP 3106 on Traverse L there is a short segment of traverse on which it seems possible to recognise the main group of reflections from about 1.6 seconds reflection time onwards (compare with SP 180 on Traverse F). This strengthens the hypothesis, similar to that propounded for Traverse F, that the 'Ninmaroo' horizon and succeeding horizons continue more or less horizontally between SP 3102 and SP 3112, disturbed in two places by relatively minor fault zones which destroy reflection quality but do not introduce any large vertical displacements. Near SP 3107, some strong deep events were recorded at about 4 seconds which indicate a dip component of about 30 degrees to the north-east. These deep events may be significant in the interpretation of the gravity profile along this traverse.

From SP 3112 to the north-eastern end of Traverse L, reflection quality was fair and a number of correlateable reflections were recorded. Reflection Traverse E crossed Traverse L between SP 3117 and SP 3118 and intersected Traverse F at SP 189. It was thus possible to correlate the 'Ninmaroo' group of reflections from SP 3112 on Traverse L via Traverse E to SP 189 on Traverse F. There was little change in the recorded time of the group over this interval (about 1.55 seconds). A reflection recorded at 1.0 second near the north-east end of Traverse L could likewise be correlated to Traverse F via Traverse E.

Between SP 3112 and SP 3118 on Traverse L a number of deep events, mostly indicating more or less horizontal strata, were recorded from 2.0 to 4.5 seconds or more. Some of these, particularly those at about 3.3 seconds, or double the time of the 'Ninmaroo' group, are probably multiples, but the events from about 4.0 seconds onwards are as strong as any recorded earlier and do not appear to be multiples. They apparently indicate strata with little dip component in the traverse direction at a depth of over 30,000 ft.

Reflection Traverse E

Three separate segments of continuous reflection profiling were shot on Traverse E between SP 1930 and SP 1947, SP 1966 and SP 1981, SP 2000 and SP 2015. These segments were 5 or 6 miles long, separated by gaps of about 6 miles. Results on the first segment, on which SP 1940 coincided with SP 189 of Traverse F, were good (Plate 79). The 'Ninmaroo reflection' could be correlated over the whole length of the segment and indicated a gentle dip to the south-east. A number of other reflections, both shallower and deeper, could be correlated over considerable distances. These all appeared to be conformable with the 'Ninmaroo reflection'.

Results on the other two segments were variable, but generally of much poorer quality than on the first. Between SP 1966 and SP 1973 the 'Ninmaroo reflection' was recognisable on only a few traces. Between SP 1973 and SP 1979 the 'Ninmaroo' group of reflections was clearly recorded and indicated gentle south-east dip. The 'Ninmaroo reflection' time had increased from about 1.6 seconds at SP 1947 to about 1.8 seconds at SP 1975. The 'Ninmaroo' group of reflections terminated abruptly near SP 1979. This fact, together with the presence at about the same record-time of south-east dipping events, which are probably diffractions, indicates the presence of a fault or fault zone near SP 1979. No reflections were recorded at SP 1980 and SP 1981 apart from a very shallow one.

Between SP 2000 and SP 2015 the quality of reflections below 0.3 second was generally poor, but it is possible to recognise the 'Ninmaroo' group of reflections from place to place across this segment of Traverse. In the vicinity of SP 2009 the 'Ninmaroo reflection' can probably be recognised at about 2.1 seconds and gentle south-east dip is still indicated. Over the whole length of Reflection Traverse E the depth of the 'Ninmaroo' horizon probably increases about 5000 ft from north-east to south-west, although reflection correlation along this discontinuous traverse is not certain.

From SP 1968 to the south-east on Traverse E, a strong shallow reflection was recorded. Its reflection time increases from 0.2 second at SP 1968 to 0.3 second at the southern end of Traverse E. It is probably associated with a marked velocity change at the base of the Mesozoic sediments. If this is so then the Mesozoic sediments would have a thickness of about 1000 ft at the southern end of Traverse E. Allowing for an increase in thickness of about 800 ft in the Mesozoic sediments along Traverse E, it is estimated that the thickness of the Palaeozoic sediments increases by about 4000 ft between Traverse F and the southern end of Traverse E.

Refraction Traverse E

A refraction depth-probe was shot on Traverse E near where it intersects Traverse F (SP 1940). This refraction probe, shot in both directions, was of the type described by Vale and Smith (1961), in which it is aimed to record from successively deeper refractors vertically beneath the same segment of traverse. The results are presented in variable-area record profile form in Plate 81 and in graphical form in Plate 82. Only one persistent refractor was recorded. This has a velocity of 20,000 ft/s.

A number of other refractors were recorded from shallower depths, with velocities ranging from about 13,500 ft/s to 17,500 ft/s, but none of these persisted over distances of much more than about a mile. For some shots the apparent velocities recorded decreased with increasing shot-to-geophone distances, indicating that there was considerable horizontal variation in these shallower refractors. The lack of persistence and rapid attenuation of energy along these refractors suggests that they represent a number of fairly thin layers. They would certainly not be suitable for exploitation as markers for continuous refraction profiling.

It is clear from Plate 81 that the strong deep refractor with velocity of 20,000 ft/s is associated with the 'Ninmaroo reflection' horizon or a horizon very close to it. Near the centre of the record profile the 'Ninmaroo reflection' is visible at 1.6 seconds and can be followed outwards on the record profile with increasing time due to normal moveout. As the shot-to-geophone distance increases, the curved shape of the reflection gives way to the straight form of the refraction time/distance graph, and on the outer records at either side, with large shot-to-geophone distances, the 'Ninmaroo' event is seen to become the first refraction arrival, with very high velocity. The depth of the refractor is about 10,000 ft in the centre of the profile. A difference in apparent velocities of 1600 ft/s recorded shooting from opposite directions indicates that the refractor dips gently to the south-east. The refraction velocity associated with the 'Ninmaroo' horizon on Traverse E near the

axis of the Toko Syncline was somewhat greater than the velocities measured for this horizon near the north-east margin of the syncline on Traverse F (19,100 ft/s) and Traverse I (17,850 ft/s). The higher velocity on Traverse E is probably due to compaction by the much greater thickness of overburden material present in this area.

As the refractor associated with the 'Ninmaroo reflection' gives such a strong energy return and has such a high velocity, it was considered impractical within the scope of the survey to try to record a basement refractor from below the Ninmaroo Formation.

Comparison of seismic and gravity results

To allow detailed correlation of seismic results with gravity data, gravity readings were taken at each shot-point of the survey (Darby, 1965). In general, the detailed gravity observations did not alter the gravity picture that had been obtained previously from regional surveys. However, on the south-western ends of Traverses F and L the gravity readings indicated detailed gravity features which made a useful contribution to interpretation of seismic data in this difficult area.

In Plate 83 the Bouguer anomaly profiles for Traverse F and L are shown plotted at the same horizontal scale as the 'Ninmaroo reflection' and a deeper seismic event on Traverse F. It can be seen that the deepest part of the Toko Syncline, as indicated by the 'Ninmaroo reflection', occurs about eight miles south-west of the axis of the Toko Syncline Gravity Low. This suggests that the principal density contrast, which determines the general shape of the gravity anomaly, is deeper than the 'Ninmaroo' group of reflections and is not conformable with it. Results on the north-eastern half of Traverse F also tend to confirm this. Assuming a density contrast of 0.1 g/cm^3, the gravity gradient on the north-eastern limb of the syncline indicates a dip of about 15 degrees, whereas the average dip of the 'Ninmaroo' reflection between SP 205 and SP 240 on Traverse F is only about 6 degrees. The gravity results indicate a minimum thickness of 20,000 ft of sediments beneath SP 205. The base of such a sedimentary section would correspond to a minimum reflection time of about 2.6 seconds, which is considerably greater than that of the 'Ninmaroo' group of reflections near SP 205.

Reference has already been made to a group of events between SP 190 and SP 205 on Traverse F after record times of about 3.1 and 3.9 seconds respectively, which could be genuine reflections and which indicate a north-easterly component of dip. One such event is shown in Plate 47 at about 3.5 seconds in the vicinity of SP 197. These events may reflect the attitude of the deep horizon at which the main density contrast occurs, since the axis of the elongated gravity 'low' observed over the Toko Syncline is in the vicinity of SP 205, to the north-east of these events. Deep events near SP 3107 on Traverse L, which also indicate north-east dip, have already been mentioned. Although some late events that indicate south-west dip were recorded to the north-east of SP 205 on Traverse F, none of these can confidently be regarded as genuine deep reflections that indicate the dip of deep horizons at which the main density contrast occurs. On the other hand, between SP 220 and SP 235, where there is a strong gravity gradient from north-east to south-west, a number of fairly

strong, more or less horizontal events were recorded from 3 seconds onwards. Thus, on the north-eastern half of Traverse F, there is no obvious correlation of deep seismic events with the gravity profile.

Comparing the portions of the gravity profile north-east and south-west of the gravity minimum near SP 205 (Plate 83), it is seen that the south-west portion of the profile approximates very closely to the mirror image of the north-eastern portion from SP 205 to SP 186. If the irregularities in the gravity profile between SP 186 and SP 167 are smoothed out, the general slope of the profile on this portion of the traverse is also similar to the corresponding portion of the gravity profile north-east of the minimum. South-west of SP 167 the gravity profile rises much more rapidly than it does at the north-eastern end of the Traverse. Thus, over the greater portion of Traverse F the gravity profile is more or less symmetrical about the minimum, if the local irregularities near the south-western end are removed. Lack of correlation with the seismic data and the generally smooth character of the gravity profile itself indicate that the origin of this approximately symmetrical gravity depression is quite deep seated. The fact that the gravity 'low' corresponds even approximately to the thick trough of Palaeozoic sediments of the Toko Syncline suggests that the gravity depression is principally caused by a depression in igneous basement, but its lack of correlation in detail with the structure of the Lower Palaeozoic sediments and also with some of the deeper reflecting horizons suggests that density changes within the basement could possibly be a factor, as they so commonly are in other parts of the Georgina Basin region.

If the smoothed-out component of the south-western portion of the gravity profile on Traverse F is removed from the Bouguer anomaly values the main residual feature is a 'high' from SP 168 to SP 178, centred on SP 173. This residual anomaly is shown plotted at the bottom left hand corner of Plate 83. The close coincidence between this residual anomaly and the strong seismic reflection feature between SP 169 and SP 176 is immediately obvious. It would seem that some connection between the two is likely. However, application of Skeels' method for determining the maximum depth of gravity anomaly-producing bodies (Skeels, 1963) indicates that the top of the residual anomaly-producing body near SP 173 is very shallow, at a depth of not more than a few hundred feet. The denser material producing the 'high is probably present immediately beneath the Mesozoic sediments at a depth of about 250 ft, the approximate depth at which very hard rocks were encountered in drill holes.

Interpretation of results near south-western margin of Toko Syncline

The most plausible explanation for the occurrence of a high-density body close to the surface that causes the gravity anomaly near SP 173 on Traverse F, while the 'Ninmaroo' group of reflections continues to be recorded at depth, is probably that the dense material was brought up from the south-west by reverse faulting, the fault planes passing to the south-west of the termination of the 'Ninmaroo' group of reflections in the vicinity of SP 170. To produce a residual anomaly similar in shape to that illustrated in Plate 83 the high-density body must be of limited width. For this reason, it is postulated that the high-density body is in the form of a south-westerly-dipping slab bounded by two more or less parallel reverse faults and by a thin layer of Mesozoic sediments above, as shown in

Figure 1 of Plate 84. This figure shows a comparison of the residual anomaly near SP 173 and the anomaly computed for the postulated model, assuming a density contrast of 0.125 g/cm^3 and a fault dip of 30 degrees to the south-west. It is seen that the calculated anomaly is about the same magnitude as that observed.

If the postulated model gives a satisfactory explanation of the observed gravity, it gives an even better explanation of the seismic results, which are difficult to explain by other means. The high density material which produces the residual gravity anomaly is probably composed of relatively old, metamorphosed sediments or igneous rocks. It is reasonable to assume that this material will have a comparatively high seismic velocity and, this being the case, the attitude of the reflections recorded from 1.4 seconds onwards between SP 170 and SP 176 can be well explained as a 'velocity structure'. It is postulated that the horizons associated with the 'Ninmaroo' group of reflections continue more or less horizontally to the south-west from SP 180 to the vicinity of SP 170. The apparent dips recorded between SP 176 and SP 173 and the reduced reflection times south-west of SP 176 are considered to be due to reflection travel paths passing through various thicknesses of high velocity material in the upper part of the section.

In Appendix D a mathematical expression has been derived which allows calculation of the effect of a dipping prism on a reflection from a horizontal horizon below it. This expression was used to calculate reflection travel times assuming that the dipping prism on Traverse F was bounded by sides dipping at an angle of 30 degrees to the south-west and was composed of material with a seismic velocity of 16,250 ft/s. It was further assumed that the prism was overlain by a layer of Mesozoic rocks 300 ft thick with a velocity of 6000 ft/s. The velocities used for the Palaeozoic sediments (medium with velocity v in Appendix D) were derived from the average t: Δt velocity curve in Plate 73. The reflection times thus calculated are shown plotted in Figure 2 of Plate 84, together with the reflection times actually recorded. It is seen that the calculated reflection times agree very closely with the recorded times between SP 176 and SP 173. The slight south-westerly dip indicated by the recorded reflections between SP 173 and SP 171 is partly to be explained by the effect mentioned in the last paragraph of Appendix D, but probably also by the fact that the base of the Mesozoic sediments dips appreciably to the south-west from SP 173 to SP 171 (see Plate 62). The increasing thickness of low-velocity Mesozoic sediments would cause an increase in reflection times to the south-west.

The hypothesis of reverse faulting appears to explain many features of the seismic and gravity results near SP 173 on Traverse F in the Pulchera Waterhole area. It is useful to consider how this hypothesis can be reconciled with an overall view of the tectonic history of the Toko Syncline.

As a result of its seismic surveys over the southern portion of the Toko Syncline in 1963 and 1964 for the French Petroleum Company (Aust.) Pty Ltd the Compagnie Generale de Geophysique concluded in their report (French Petroleum Company (Aust.) Pty Ltd, 1965) that the south-western limit of the Toko Syncline is faulted, but that the location of the fault, and presumably its nature, are hard to determine because of the occurrence of a wide zone with poor results.

The Toko Syncline was seen as a monocline dipping to the south-west rather than as a syncline. Reflections from the Palaeozoic sediments on the BMR traverses tend to confirm this view.

In the Toko Range outcrop area to the north, Reynolds (1964) and Smith (in preparation) see the Toko Syncline as a very asymmetrical syncline with steep dips near the western margin. These indications of an asymmetrical depression are difficult to reconcile with the implications of the Toko Syncline Gravity Low, which is more or less symmetrical and centred about 10 miles north-east of the deepest part of the Palaeozoic depression. Certainly the elongated gravity 'low' could be interpreted as resulting from a density change within basement, but as it occurs in the vicinity of a known sedimentary trough, such an interpretation would appear to dodge the issue. It is considered that the most likely explanation is that the position of the deepest part of the sedimentary trough moved considerably to the south-west between the early stages of deposition in the Proterozoic and deposition in Palaeozoic times.

The conclusions from seismic and gravity evidence on Traverse F that reverse faulting occurs at the south-western margin of the Toko Syncline are not without supporting geological evidence from the outcrop areas to the north. Reynolds (1964, p 18) states that: "A major thrust from the south-west during the ?Carboniferous caused extensive faulting, mostly steep and some reverse, along the western edge of the Toko trough. The main fault line, the Toomba Fault, is irregular and disrupted by cross-faults some of which show transverse movement. ... The Middle Cambrian to Devonian succession in the western part of the Toko trough was upturned and overturned against the fault, and an asymmetrical structure with steep westerm limb and low-dipping eastern limb, the Toko Syncline, was formed".

Taking into account the known facts, an attempt has been made to formulate a possible tectonic history of the Toko Syncline in the vicinity of Traverse F. This is illustrated in diagrammatic form in Figures 3a to 3e of Plate 84. It is postulated that sedimentation began in Proterozoic times in a subsiding trough (Fig. 3a). The trough was subjected to horizontal compression resulting in a mid-trough ridge (Fig. 3b). In Palaeozoic times subsidence continued with little or no compression while the Palaeozoic sediments were deposited (Figure 3c). Strong horizontal compressive forces resumed in later Palaeozoic times and these resulted in reverse or overthrust faulting in the vicinity of the Proterozoic mid-trough ridge (Fig. 3d). A series of more or less parallel fault planes were developed, with intensity of movement generally decreasing to the north-east. The final result of the faulting is believed to be as shown in Figure 3e, with the south-western side of the Palaeozoic syncline thrust up and eroded off. This latter hypothesis is in agreement with the opinion of Reynolds and Pritchard (1964) that "a major thrust from the south-west is thought to have brought sedimentation in the Georgina Basin to a close".

It appears that the intensity of thrust faulting decreased from south to north. In the Toomba Range area, fault planes at the south-western margin of the syncline are more or less vertical. These are probably separated from comparatively low-angle reverse faults on the same line to the south by cross-faults. It should be

noted also that north of latitude 23 degrees Lower Palaeozoic sediments extend much further west than they do to the south. It is suggested that Lower Palaeozoic sediments similar to those seen in the Tarlton Range area once extended far to the south-east across the Field River area. In the south they have been thrust up and eroded off leaving Proterozoic Field River Beds or granite exposed where not covered by sand.

6. CONCLUSIONS AND RECOMMENDATIONS

The seismic surveys in 1963 and 1964 ranged over a large area of the south-eastern Georgina Basin in which surface and sub-surface conditions varied considerably. It is therefore not surprising that the effectiveness of the reflection seismic method varied from area to area. The results indicated that using a moderately elaborate technique the reflection method is very effective for mapping structure in a large part of the Toko Syncline. The effectiveness of the method decreases somewhat near the south-western margin of the syncline where the sediments are apparently more disturbed tectonically. Multiple reflections are sometimes a problem in mapping the deeper horizons in the Toko Syncline, but these can be attenuated to some extent by employing multiple coverage techniques.

No reflections were obtained in the Herbert Downs area where Lower Palaeozoic carbonate rocks were outcropping or were covered by a thin layer of Mesozoic and Recent sediments. No great effort was made to develop a successful reflection technique in this area as there was no indication that a reasonable thickness of sediments was present. Elsewhere in the south-eastern Georgina Basin outside the Toko Syncline the reflection method generally produced some useful results, even if only from shallow depths, but in these areas it is advisable to use a very heavy reflection technique to make the method worthwhile.

In the Toko Syncline the refraction method is useful for identifying the 'Ninmaroo reflection', since this is associated with a horizon with very high refraction velocity. However, because of the good quality of reflections and the absence of other persistent refractors, the refraction method is not recommended for structural mapping in the Toko Syncline. In the area south-east of Herbert Downs it was easily possible to map the unconformity at the base of the Mesozoic using the refraction method, but it was not possible to determine Palaeozoic structure by mapping a single distinctive refractor within the Lower Palaeozoic, as these rocks apparently consist of many high velocity beds whose velocities differ only slightly from one another. In the eastern part of the survey area, between Marion Downs and Canary, refraction depth probes provided useful information in addition to information gained from reflection shooting, but here again the effectiveness of the refraction method is limited by lack of distinctive velocity contrasts below the base of the Mesozoic.

The survey objective of providing a seismic tie between Upper Proterozoic rocks near Sylvester Creek and in Canary No. 1 Bore was only partly achieved because of the absence of persistent reflecting horizons and because of poor reflection results

in some areas. However, results indicate fairly conclusively that no deep troughs of Palaeozoic sediments comparable to the Toko Syncline occur in this area. A scout hole confirmed that some Lower Palaeozoic sediments are present beneath the Mesozoic on Traverse A north-east of Marion Downs. It is probable from the seismic results that Palaeozoic sediments underlie the Mesozoic elsewhere in the area, but that the thickness of these sediments is small. Deep reflections recorded on many parts of the traverses between Sylvester Creek and Canary suggest that much of the area is underlain by a considerable thickness of Proterozoic sediments, although there are seismic indications that there may be intrusions of igneous rocks in two areas of low Bouguer gravity anomaly. Elsewhere to the north-east of the Toko Syncline the seismic results show no obvious correlation with gravity anomalies.

The survey was successful in proving that the Toko Syncline extends south-east across the Mount Whelan 1:250,000 map area from th Toko Range outcrop area. It was shown that the main reflection, recorded across the greater part of the Toko Syncline in the Yarrandilla - Montara - Pulchera area, very likely corresponds to a horizon in the Lower Ordovician Ninmaroo Formation. This horizon reaches a maximum depth of about 10,300 ft on Traverse F in this area, but Lower Palaeozoic sediments conformable with this horizon probably extend to a depth of about 15,000 ft. There are both seismic and gravity indications that there are other sediments below this depth. These are likely to be Proterozoic in age and probably attain a maximum depth of the order of 30,000 ft in the vicinity of Montara Waterhole. There is evidently an unconformity between the deeper Proterozoic(?) and the Palaeozoic sediments. The deepest part of the Palaeozoic Toko Syncline, as indicated by the 'Ninmaroo reflection', is about eight miles south-west of the underlying Proterozoic(?) syncline, whose structure is apparently much more strongly reflected by the gravity results. The thicknesses of sediments gradually increase for at least 25 miles to the south-east from Traverse F towards Lake Wickamunna.

The survey indicated that there are probably considerable thicknesses of post-Ordovician and pre-Mesozoic sediments in the Toko Syncline. Such sediments are practically unknown in outcrop in the area apart from the occurrence of Upper Silurian - Lower Devonian fish scales in samples from shot-holes in the Toko Range further to the north-west. The determination of the ages and lithological types of the post-Ninmaroo sediments in the syncline is one of the most important regional objectives still to be attained in the search for hydrocarbons in the south-eastern Georgina Basin. Some stratigraphic drilling at selected sites on the uncomplicated north-eastern limb of the Toko Syncline in the area of the BMR seismic survey would appear to be very desirable to provide information on the ages and petroleum prospects of these sediments.

The seismic results tend to confirm the presence, suggested by geological and gravity evidence, of large-scale faulting near the south-western margin of the syncline. There are strong indications that this faulting may be of the reverse or overthrust type. This could best be confirmed by drilling. Such confirmation could have an important bearing on the location of structural traps for hydrocarbons in the deeper, south-western part of the syncline.

7. REFERENCES

BARLOW, B. C. 1966 Georgina Basin reconnaissance gravity surveys using helicopters, Northern Territory and Queensland, 1960-1961. Bur. Min. Resour. Aust. Rec. 1966/147.

DARBY, F. 1965 Gravity readings along seismic traverses, central and southern Queensland 1963. Bur. Min. Resour. Aust. Rec. 1965/91.

DIX, C. H. 1952 SEISMIC PROSPECTING FOR OIL. New York, Harper and Brothers.

FRENCH PETROLEUM COMPANY (AUST) PTY LTD 1965 Bedourie seismic and gravity survey. January-November 1964. *

GIBB, R. A. 1966 Western Queensland reconnaissance gravity surveys, 1957-1961. Bur. Min. Resour. Aust. Rec. 1966/13.

HAGEDOORN, J. G. 1954 A process of seismic reflection interpretation. Geophys. Prosp. 2 (2), 85 - 127.

JEWELL, F. 1960 Great Artesian Basin aeromagnetic reconnaissance survey, 1958. Bur. Min. Resour. Aust. Rec. 1960/14.

LONSDALE, G. F. 1962 Great Artesian Basin reconnaissance gravity survey using helicopters, Queensland 1961. Bur. Min. Resour. Aust. Rec. 1962/14.

MILTON, B. E., and SEEDSMAN, K. R. 1961 Seismic survey 1960, Great Artesian Basin, South Australia and Queensland. Prelim. Rep. S. Aust. Min. Dept., 1961/60.

MULDER, C. J. 1961 The geology of the Georgina Basin. Bataafse Internationale Petroleum Maatschappij N.V. Report.

MUSGRAVE, A. W. 1962 Applications of the expanding reflection spread. Geophysics 27 (6), 981 - 993.

NEUMANN, F. J. G. 1959a Preliminary report on a reconnaissance gravity survey in the Georgina Basin area, Qld. Bur. Min. Resour. Aust. Rec. 1959/8.

NEUMANN, F. J. G. 1959b Preliminary report on a reconnaissance gravity survey in the Toko Range area, Western Queensland. Bur. Min. Resour. Aust. Rec. 1959/51.

PAPUAN APINAIPI PETROLEUM COMPANY LTD	1962	Boulia gravity survey, Queensland 1959. Bur. Min. Resour. Aust. P.S.S.A. Rept. 37.
PAPUAN APINAIPI PETROLEUM COMPANY LTD	1965	Netting Fence No. 1 Well Completion Report Q/54P/214. *
PHILLIPS PETROLEUM COMPANY	1961	Seismograph survey of the Boulia area, ATP 54P, Queensland. *
PHILLIPS PETROLEUM COMPANY	1963	Phillips - Sunray stratigraphic drilling, ATP 54P, Queensland. Unpublished Company report.
REYNOLDS, M. A.	1960	Geology of the Springvale 4-mile Sheet area, Queensland. Bur. Min. Resour. Aust. Rec. 1960/92.
REYNOLDS, M. A.	1964	Explanatory notes on the Mount Whelan geological sheet. Bur. Min. Resour. Aust. Rec. 1964/138.
REYNOLDS, M. A., and PRITCHARD, P. W.	1964	Geology of the Glenormiston 1:250,000 sheet area. Bur. Min. Resour. Aust. Rec. 1964/28.
SKEELS, D. C.	1963	An approximate solution of the problem of maximum depth in gravity interpretation. Geophysics, 28 (5,i), 724 - 735.
SMITH, K. G.	--	Geology of the Georgina Basin. Bur. Min. Resour. Aust. Bull. (in preparation).
SMITH, M. K.	1956	Noise analysis and multiple seismometer theory. Geophysics, 21 (2), 337 - 360.
VALE, K. R., and SMITH, E. R.	1961	The 'depth probing' technique using seismic refraction methods. Bur. Min. Resour. Aust. Rec. 1961/79.
WELLS, R., MILSOM, J. S., and TIPPER, D. B.	1966	Georgina Basin aeromagnetic survey, Queensland and Northern Territory, 1963 - 1964. Bur. Min. Resour. Aust. Rec. 1966/142.

* Unpublished report on a Commonwealth-subsidised operation

APPENDIX A

Staff and equipment

Staff for 1963

Party Leader	: C. S. Robertson
Geophysicists	: P. Jones
	G. Allen
Surveyors	: B. Maloney
	R. Leetham or T. McDiarmid
Observer	: G. Abbs
Junior Observer	: G. Jennings
Shooter	: R. Cherry
Toolpusher	: B. Findlay
Drillers	: R. Larter
	A. Zoska
Drilling assistants	: E. H. Cherry
	B. Peut
Mechanics	: T. Clark
	D. McIntyre
Clerk	: W. Rossendell

Twelve wages employees were also employed for the duration of the survey. These included cooking staff, field-hands, and drill helpers.

Equipment for 1963

Seismic amplifiers	: H.T.L. 7000B
Seismic oscillograph	: Electro-Tech ER66, six-inch, 27-trace
Magnetic recorder	: Electro-Tech DS7-7
Geophones	: Hall-Sears HSJ (approx. 900) for reflection work
	Electro-Tech 4.5 c/s (104) for refraction work
Drills	: Two Mayhew 1000, one Carey shot-hole rig
Water tankers	: Three Bedford RLHC3, 4 x 4, with 600-gallon cylindrical tanks
	One Bedford RLHC3, 4 x 4, with 800-gallon flat tank
Shooting truck	: Bedford RLHC3, 4 x 4, with 600-gallon cylindrical tank

Recording truck	: International AA120, 4 x 4, with BMR-Ansair cab
Geophone trucks	: Two Landrovers, LWB

Two more Landrovers, a one-ton utility, a three-ton supply truck, a workshop truck, an office caravan, and a number of four-wheel trailers completed the party's mobile equipment.

Staff for 1964

Party Leader	: P. Jones
Geophysicists	: G. Allen
	P. Montecchi
Surveyors	: T. McDiarmid
	R. Leetham
Observer	: G. Jennings
Clerk	: R. J. Cherry
Shooter	: R. D. Cherry
Toolpusher	: B. Findlay
Drillers	: R. Larter
	A. Zoska
Drilling assistants	: E. H. Cherry
	E. Lodwick
Mechanics	: T. Clark
	D. McIntyre

Thirteen wages employees were also employed for the duration of the survey. These included cooking staff, field-hands, drill helpers etc.

Equipment for 1964

Seismic amplifiers	: H.T.L. 7000B
Seismic oscillograph	: Electro-Tech ER 66, six-inch, 27-trace
Magnetic recorder	: Electro-Tech DS7-7
Geophones	: Hall-Sears HSJ (1229) for reflection work
	Electro-Tech 4.5 c/s (104) for refraction work
Water tankers	: 3 Bedford RLHC3, 4 x 4, with 600-gallon cylindrical tanks
	1 Bedford RLHC3, 4 x 4, with 800-gallon flat tank
Drills	: 2 Mayhew 1000, 1 Carey shot-hole rig

Shooting truck	: Bedford RLHC3, 4 x 4, with 600-gallon cylindrical tank
Recording truck	: International AB120, 4 x 4, with BMR-Ansair Cab
Geophone truck	: 2 Landrovers, LWB

Two more Landrovers, a one-ton utility, a three-ton supply truck, a workshop truck, an office caravan, a kitchen caravan and a number of four-wheel trailers completed the party's mobile equipment.

APPENDIX B

Table of operations

General information for 1963

Sedimentary basin	: South-eastern Georgina Basin
Area of survey	: Boulia - Bedourie
Camp sites near	: Marion Downs, Montara Bore, Humpy Creek
Established first camp	: 23rd April 1963
Surveying commenced	: 23rd April 1963
Drilling commenced	: 26th April 1963
Shooting commenced	: 29th April 1963
Survey concluded	: 26th October 1963
Miles surveyed	: 122
Topographic survey control	: Division of National Mapping 4-mile series Department of Interior bench-marks, Queensland State Datum
Total footage drilled	: 96,397 (mainly five or seven-hole reflection patterns)
Explosives used	: 11.2 short tons Geophex 1 short ton ammonium nitrate
Datum level for corrections	: 300 ft above mean sea level
Weathering velocities	: 1200 - 1300 ft/s
Sub-weathering velocities	: 6000 - 6500 ft/s
Method for weathering corrections	: Uphole times checked by first breaks
Source of velocity distribution	: t:Δt analysis on Traverses A, D, and F Velocity profiles on Traverses E and H

Reflection shooting data for 1963

Shot-point interval	: 1800 ft and 600 ft
Geophone group	: 16 geophones per trace in line along traverse, spaced 10 ft or 19.25 ft apart
Geophone group interval	: 150 ft or 50 ft depending on shot-point interval (1800 ft or 600 ft)
Number of miles traversed	: 78
Common shooting depths	: Traverse A - 90 ft Traverse D and part of E - 60 ft Other traverses - 45 ft

Usual recording filters	: 18K - 160K
Usual playback filters	: 18K - 66K
Common charge sizes	: Traverse A - 1 x $2\frac{1}{2}$ lb
Common charge sizes	: Traverse D - 5 x $1\frac{1}{4}$ lb
	Other traverses - 7 x $2\frac{1}{2}$ lb

Refraction shooting data for 1963

Geophone group	: Four geophones per trace in line perpendicular to traverse, spaced 22 ft apart
Geophone group interval	: 300 ft
Number of shot-points fired	: 98
Usual recording filter	: None
Number of refraction traverses	: 10
Common charge sizes	: 10 to 300 lb
Maximum shot-to-geophone distance	: 10 miles
Weathering control	: From reflection shooting data, from uphole time (shot-points only), and from shallow refraction shots

General information for 1964

Sedimentary basin	: South-eastern Georgina Basin
Area of survey	: Boulia - Bedourie
Camp sites near	: Bucket Creek, Hamilton River, Hilary Dam, Montara Bore
Established first camp	: 27th March 1964
Surveying commenced	: 31st March 1964
Drilling commenced	: 1st April 1964
Shooting commenced	: 1st April 1964
Survey concluded	: 23rd October 1964
Miles surveyed	: 127
Topographic survey control	: Division of National Mapping 4-mile series
	Department of Interior bench-marks, Queensland State Datum
Total footage drilled	: 214,960 ft (including 13,140 ft drilled by Petty Geophysical Engineering Co. under contract)
Explosive used	: 14 short tons Geophex

Datum level for corrections	: 400 ft above mean sea level (Traverses N and O) 300 ft above mean sea level all other traverses
Weathering velocities	: 1200 - 2000 ft/s
Sub-weathering velocities	: 6000 - 8500 ft/s
Method for weathering corrections	: Uphole times checked by first breaks
Source of velocity distribution	: t:Δt analysis on traverses A and V Velocity profiles on Traverses T, U, and W

Reflection shooting data for 1964

Shot-point interval	: 1800 ft and 900 ft
Geophone group	: Unit group eight geophones, with 20 ft between geophones. Connected in various combinations from 8 to 32
Geophone group interval	: 150 ft or 75 ft 300 ft - Traverse F multiple coverage
Number of shot-points fired	: 667
Number of miles traversed	: 100
Common shooting depths	: 45 ft or 60 ft
Usual recording filter	: 18K - 160K or 18K - 120K (Traverses N, R, and A) 24K - 160K or 24K - 120K (Traverses V, B, S, and A) 18K - 92K (Traverse F)
Usual playback	: 24K - 92K 18K - 66K (Traverse F)
Common charge sizes	: 5 x 2½ lb, 5 x 5 lb, 5 x 10 lb, 7 x 2½ lb, 7 x 5 lb

Refraction shooting data for 1964

Geophone group	: 4 geophones per trace in line perpendicular to traverse, spaced 22 ft apart Into reflection spreads (Traverse V)
Geophone group interval	: 300 ft 150 ft (Traverse V)
Number of shot-points fired	: 52
Number of refraction traverses	: 4

Common charge sizes	: 5 to 100 lb
Maximum shot-to-geophone distance	: 4-2/3 miles
Weathering control	: From reflection shooting data, from uphole times (shot-points only) and from shallow refraction shots

APPENDIX C

Shot-hole drilling statistics

For 1963 *

	Mayhew 1000 ZDA 064	Mayhew 1000 ZDA 094	Carey C13648	Totals
Total footage drilled	74,264	57,013	4,681	135,958
Total number of holes	1,285	1,072	77	2,434
Average depth (ft)	57	53	60	55
Deepest hole (ft)	360	500	66	500
Drilling time (hours)	527½	699½	64½	1,291½
Rate of penetration (ft/h)	140	81	73	105
Number of 8½-hr shifts worked	146	134	13	293
Maintenance time (hours)	107½	94½	7	209
Time travelling and rigging up (hours)	540	294½	36½	871
Hours lost waiting on water	55	41	3½	99½
Hours lost repairs to drill	25½	22	1	48½
Hours lost because of rain				
Hours lost repairs to rig engine	5	2½		7½
Hours lost waiting on surveyors				
Hours lost puplic holidays				
Hours lost standing by recorder	5	9½		14½
Bentonite used (bags)	8	16½		24½
Time running casing and bailing (hours)				
Time on fishing (hours)	6			6
Time freeing bogged vehicles	11			11

* Statistics include survey near Thargomindah from 28.9.63 to 30.11.63 in which total footage of 38,713 was drilled (28.5% of yearly total)

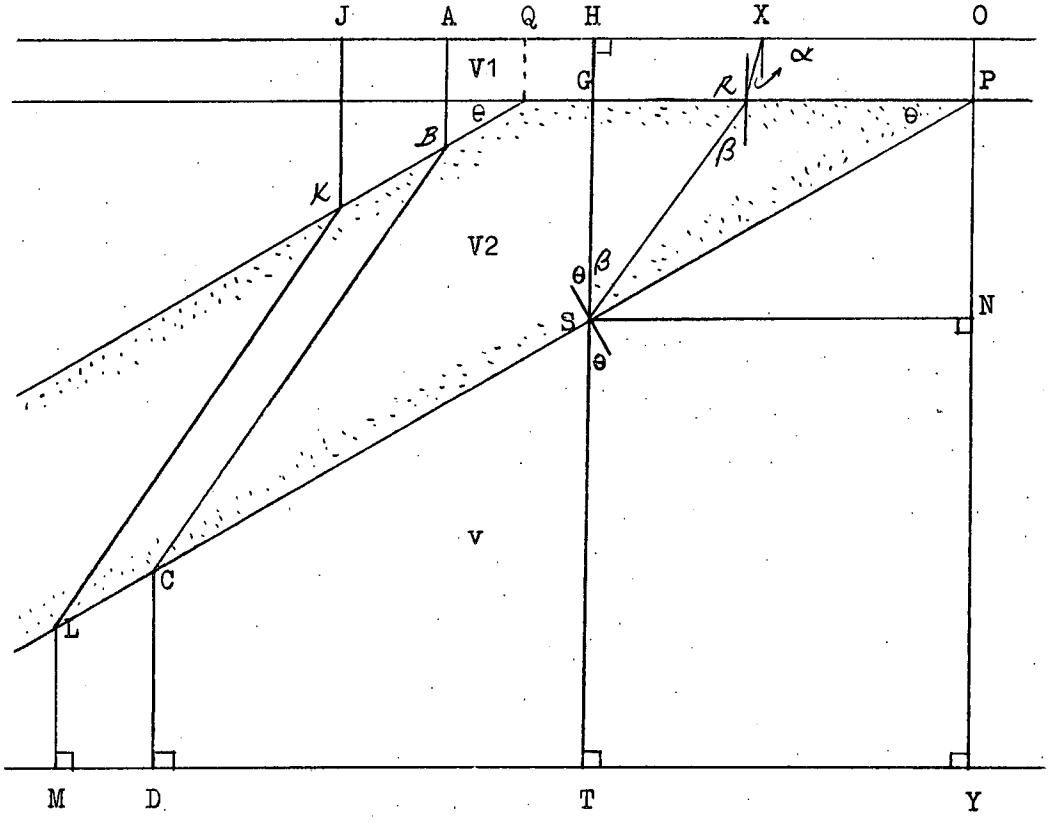
For 1964 *

	Mayhew 1000 ZDA 064	Mayhew 1000 ZDA 094	Carey ZSU 110	Totals
Total footage drilled	94,485	85,782	34,198	214,395
Total number of holes	1,833	1,597	670	4,100
Average depth (ft)	51	53	51	52
Deepest hole (ft)	285	472	70	472
Drilling time (hours)	736	685½	535½	1,957
Rate of penetration (ft/hr)	128	125	63	109
Number of 8½-hr shifts worked	150	147	95	392
Maintenance time (hours)	138	129	76	343
Time travelling and rigging up (hours)	392	468	182	1,042
Hours lost waiting on water	12½	8½	10	31
Hours lost repairs to drill	28	7½	65	100½
Hours lost because of rain	56	62½	25½	144
Hours lost repairs to rig engine	6		8½	14½
Hours lost waiting on surveyors				
Hours lost public holidays	8½	8½		17
Hours lost standing by recorder	20	1		21
Bentonite used (bags)	38	61		99
Time running casing and bailing (hours)				
Time on fishing job (hours)	3½			3½
Time freeing bogged vehicles				

* Statistics include survey near Cockroach Bore, NT from 26.10.64 to 26.11.64 in which total footage of 8083 was drilled (3.8% of yearly total)

APPENDIX D

Calculation of the effect of a dipping prism on a reflection



The above figure represents a cross-section through a medium with velocity v, which is overlain by a thin layer with velocity V1. Imbedded in the medium with velocity v is a prism of material with velocity V2 and with sides dipping at an angle θ. MY represents a horizontal reflecting plane at a depth OY beneath the surface.

Consider a reflected ray path XRST between the surface OX and the reflecting plane MY. It is required to determine the emergent angle α of this ray at the surface and also the travel time XRST.

From Snell's law $$\frac{\sin \alpha}{\sin \beta} = \frac{V1}{V2}$$

and $$\frac{\sin \theta}{\sin (\theta + \beta)} = \frac{v}{V2}$$

Thus $$\sin \alpha = \frac{V1}{V2} \sin \beta \quad \ldots\ldots (1)$$

where $$\sin (\theta + \beta) = \frac{V2}{v} \sin \theta \quad \ldots\ldots (2)$$

Now $\frac{RS}{\sin\theta} = \frac{RP}{\sin[90 - (\theta + \beta)]}$

$RS = \frac{RP \sin\theta}{\cos(\theta + \beta)}$

$= \frac{(OX + OP \tan\alpha) \sin\theta}{\cos(\theta + \beta)}$ ..... (3)

Also, $\frac{PS}{\sin(90 + \beta)} = \frac{RP}{\sin[90 - (\theta + \beta)]}$

$\frac{PS}{\cos\beta} = \frac{RP}{\cos(\theta + \beta)}$

$\therefore PS = \frac{(OX + OP \tan\alpha) \cos\beta}{\cos(\theta + \beta)}$ ..... (4)

Now $ST = OY - (OP + PN)$

$= OY - OP - PS \sin\theta$

$\therefore$ From (4), $ST = OY - OP - \frac{(OX + OP \tan\alpha) \cos\beta \sin\theta}{\cos(\theta + \beta)}$

..... (5)

Travel path $XRST = XR + RS + ST$

Travel time $XRST = \frac{XR}{V1} + \frac{RS}{V2} + \frac{ST}{v}$

From (3), (4), and (5),

Travel time $XRST = \frac{OP}{V1 \cos\alpha} + \frac{(OX + OP \tan\alpha) \sin\theta}{V2 \cos(\theta + \beta)}$

$+ \frac{OY - OP}{v} - \frac{(OX + OP \tan\alpha) \cos\beta \sin\theta}{v \cos(\theta + \beta)}$

..... (6)

Horizontal offset

$HX = OP \tan\alpha + PN \tan\beta$ ..... (7)

Now it will be noted from the figure that, if V2 is greater than v and if v is constant, reflection times recorded between O and Q will decrease uniformly from right to left because of the increasing path through the material of higher velocity. Left of the point Q the reflection times will be constant but less than at O (see paths ABCD and JKLM).

However, if the velocity v increases with depth, the decrease in reflection times observed from O to Q will not be uniform but will be more rapid at first, since at shallow depths the contrast between the velocities V2 and v will be greatest. Moreover, to the left of point Q the reflection times will not remain constant but will increase slightly as the portions AB, JK, ... of the reflection travel paths in the upper, slower part of the medium with velocity v become longer.

PLATE 1

SEISMIC SURVEY, SE GEORGINA BASIN, QLD 1963-64

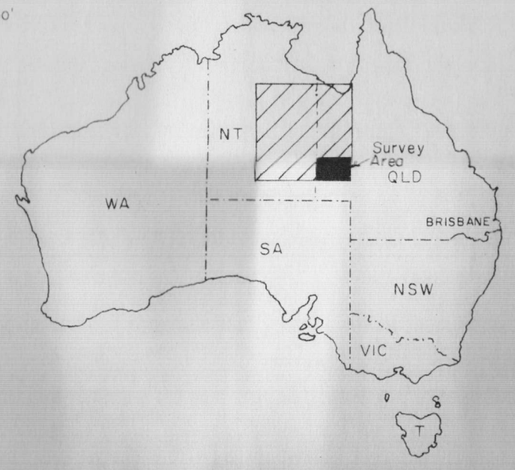
GEOLOGY AND LOCALITY MAP

Cz Undifferentiated Cainozoic
T Tertiary
M Undifferentiated Mesozoic
Pzu Upper Palaeozoic
Pzm Middle Palaeozoic
Pzl Lower Palaeozoic
Puu Upper Upper Proterozoic
Plu Upper Lower Proterozoic
P Undifferentiated Proterozoic
Pg Proterozoic and igneous rock
Pll Lower Lower Proterozoic
V V V Basic Volcanics

Geological boundary
Geological boundary, indefinite
Bedding strike and dip direction
Basin
Dome
Horizontal beds
Fault
Anticlinal axis
Synclinal axis
Town
Homestead
Boundary of survey area

40 0 40 80 120 MILES
40 0 40 80 120 160 200 KILOMETRES

Generalised Geology after the Tectonic Map of Australia
(Bureau of Mineral Resources, 1960)

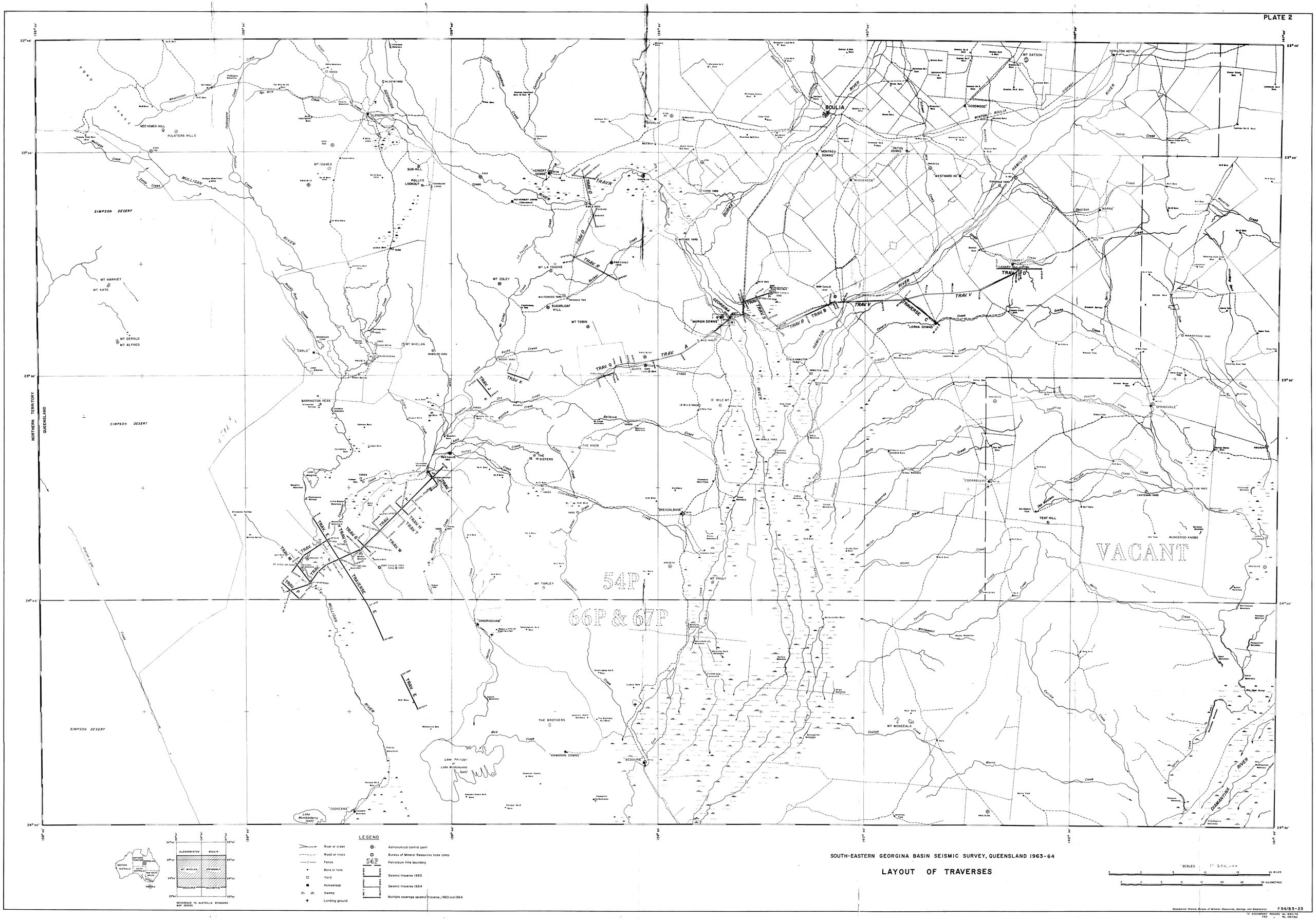


To accompany Record No. 1965/75
and „ No. 1967/90

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

E53/B3-1

PLATE 2



REFERENCE TO AUSTRALIA STANDARD MAP SERIES.

LEGEND

- River or creek
- Road or track
- Fence
- Bore or tank
- Yard
- Homestead
- Swamp
- Landing ground
- Astronomical control point
- Bureau of Mineral Resources base camp
- Petroleum title boundary
- Seismic traverse 1963
- Seismic traverse 1964
- Multiple coverage seismic traverse, 1963 and 1964

SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QUEENSLAND 1963-64

LAYOUT OF TRAVERSES

SCALES 1" = 250,000

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. F54/B3-23

TO ACCOMPANY RECORD No. 1965/78
AND No. 1967/90

SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QUEENSLAND 1963-64

BOUGUER ANOMALY CONTOURS IN RELATION TO SEISMIC TRAVERSES

LEGEND

- River or creek
- Road or track
- Fence
- Bore or tank
- Yard
- Homestead
- Swamp
- Landing ground
- Astronomical control point
- Bureau of Mineral Resources base camp
- Petroleum title boundary
- Seismic traverse 1963
- Seismic traverse 1964
- Multiple coverage seismic traverse, 1963 and 1964
- 'High' anomaly
- 'Low' anomaly
- Isogal

REFERENCE TO AUSTRALIA STANDARD MAP SERIES

SCALES

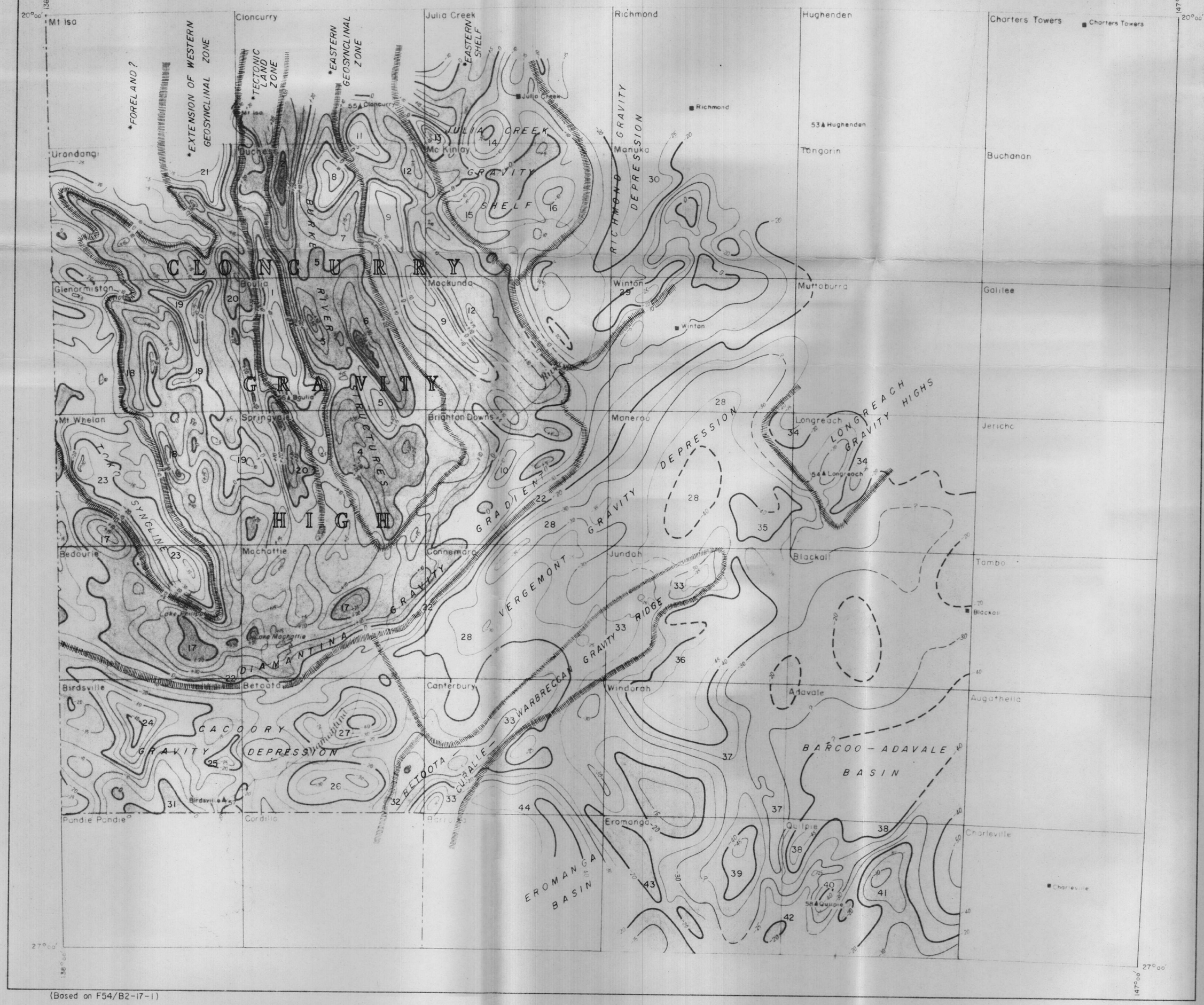
Contour interval 5 milligals

Geological Branch, Bureau of Mineral Resources, Geology and Geophysics

F54/83-23-1

TO ACCOMPANY RECORD No. 1966/79 AND " No. 1967/90

PLATE 4



(Based on F54/B2-17-1)

LEGEND

- Isogals, values in milligals
- ▲ 56 — BMR gravity pendulum station
- Mt Isa — BMR 4-mile gravity map area
- Gravity 'High'
- Gravity 'Low'
- 12 — Anomaly number after Gibb, 1966

Bouguer anomalies are based on the observed gravity values at B.M.R. pendulum stations:

No. 54 Longreach	978,783.6	milligals
No. 55 Cloncurry	978,650.7	"
No. 56 Boulia	978,793.2	"
No. 57 Birdsville	979,003.0	"
No. 58 Quilpie	979,006.5	"

For the calculation of Bouguer anomalies 2.67 g/cm³ has been adopted as an average rock density.

Elevation datum Queensland State.

* After Carter, Brooks and Walker (1961)

Compiled September 1960
Revised November 1961, July 1962, January 1963

S-E GEORGINA BASIN SEISMIC SURVEY 1963-64

QUEENSLAND

BOUGUER ANOMALIES

WITH SHADING EMPHASIS AND GRAVITY UNITS

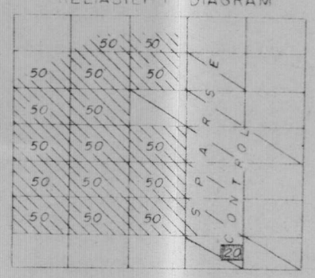
SCALE IN MILES

0 20 40 80 120

Reference – Division of National Mapping 40 miles to 1 inch topographic map

CONTOUR INTERVAL 5 MILLIGALS

RELIABILITY DIAGRAM



GRAVITY SURVEY	METHOD
HELICOPTER BY BMR	REGULAR GRID COVERAGE, AIR PHOTOGRAPHY, BAROMETRIC LEVELLING.
GROUND TRAVERSES BY BMR	WIDELY DISPERSED TRAVERSES, AIR PHOTOGRAPHY, CONVENTIONAL LEVELLING, ASTROFIXES.
SEMI-DETAILED BY GEOSURVEYS	GROUND TRAVERSES, CONVENTIONAL LEVELLING.

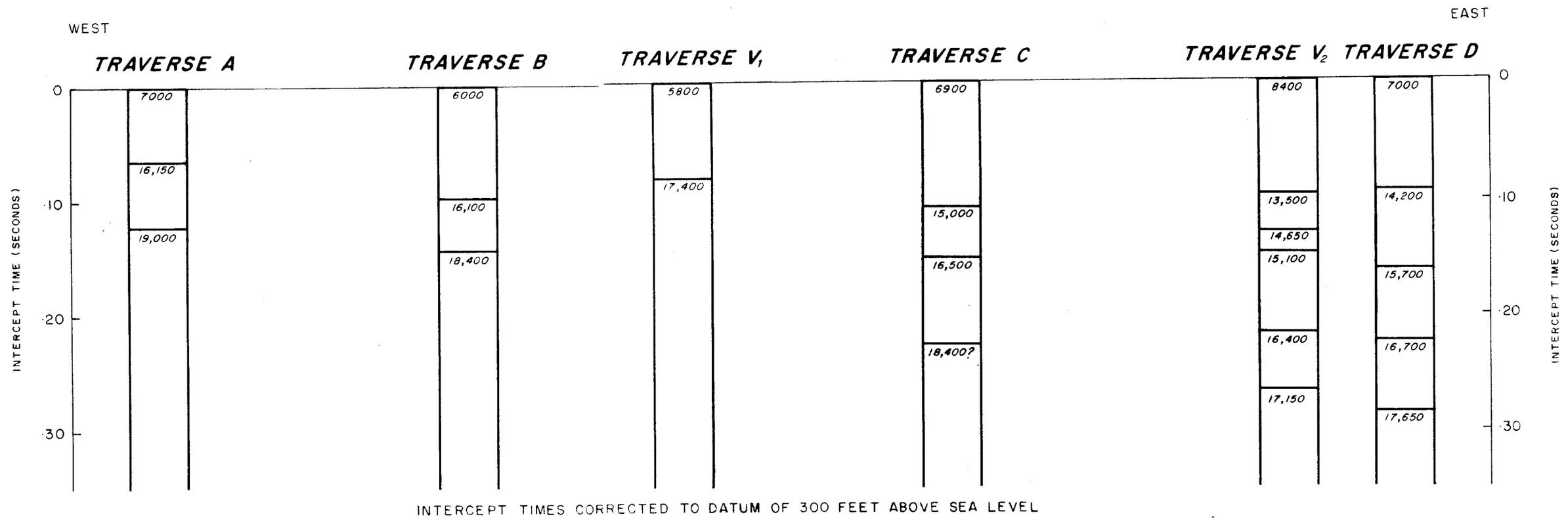
FIGURE IN EACH AREA DENOTES SQUARE MILES PER ONE GRAVITY STATION

TO ACCOMPANY RECORD No. 1965/75
AND " No. 1967/90

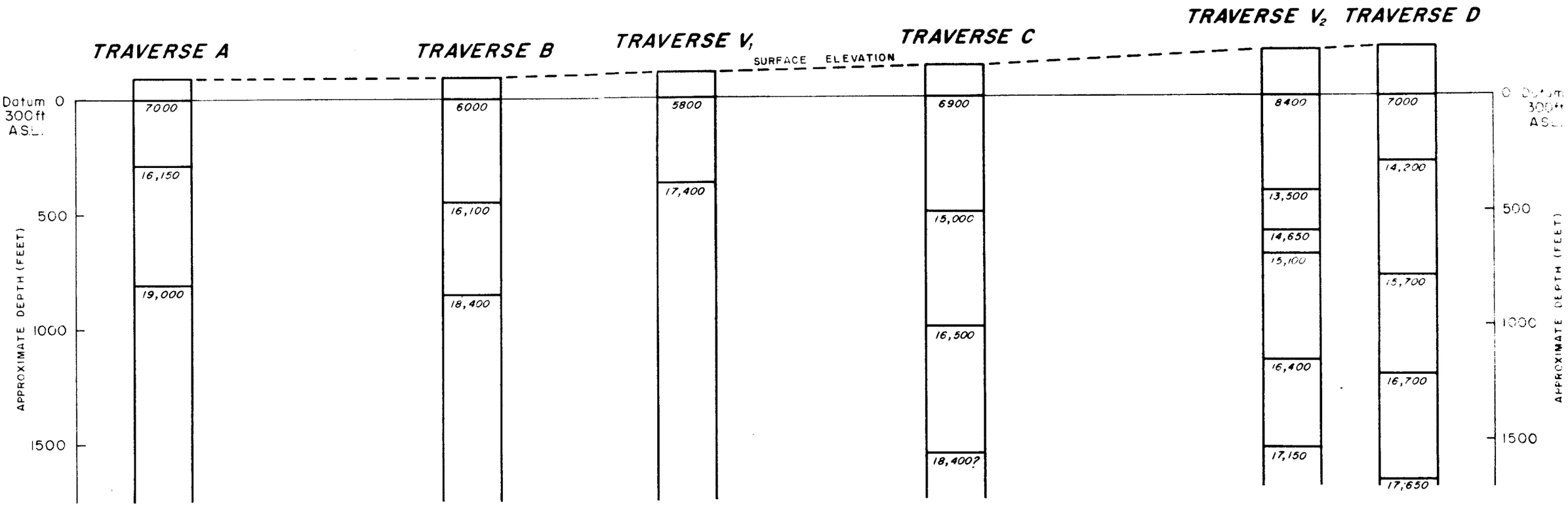
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

F54/B3-48

PLATE 5



INTERCEPT TIMES CORRECTED TO DATUM OF 300 FEET ABOVE SEA LEVEL



APPROXIMATE DEPTHS OF REFRACTORS

SUMMARY OF REFRACTION DEPTH-PROBE RESULTS ON TRAVERSES A,B,V_1,C,V_2 AND D

MARION DOWNS – CANARY

LEGEND

16,150 Seismic velocity (ft/s) in formation

HORIZONTAL SCALE
FEET (Approx.)

20,000 0 20,000 40,000 60,000

(Vertical scales as shown)

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. F54/B3-47-1

TO ACCOMPANY RECORD No 1967/90

PLATE 6

SHOT FROM S.W. TO N.E — POINTS SHOWN x

SP. 1005 ds = 46-54 ft

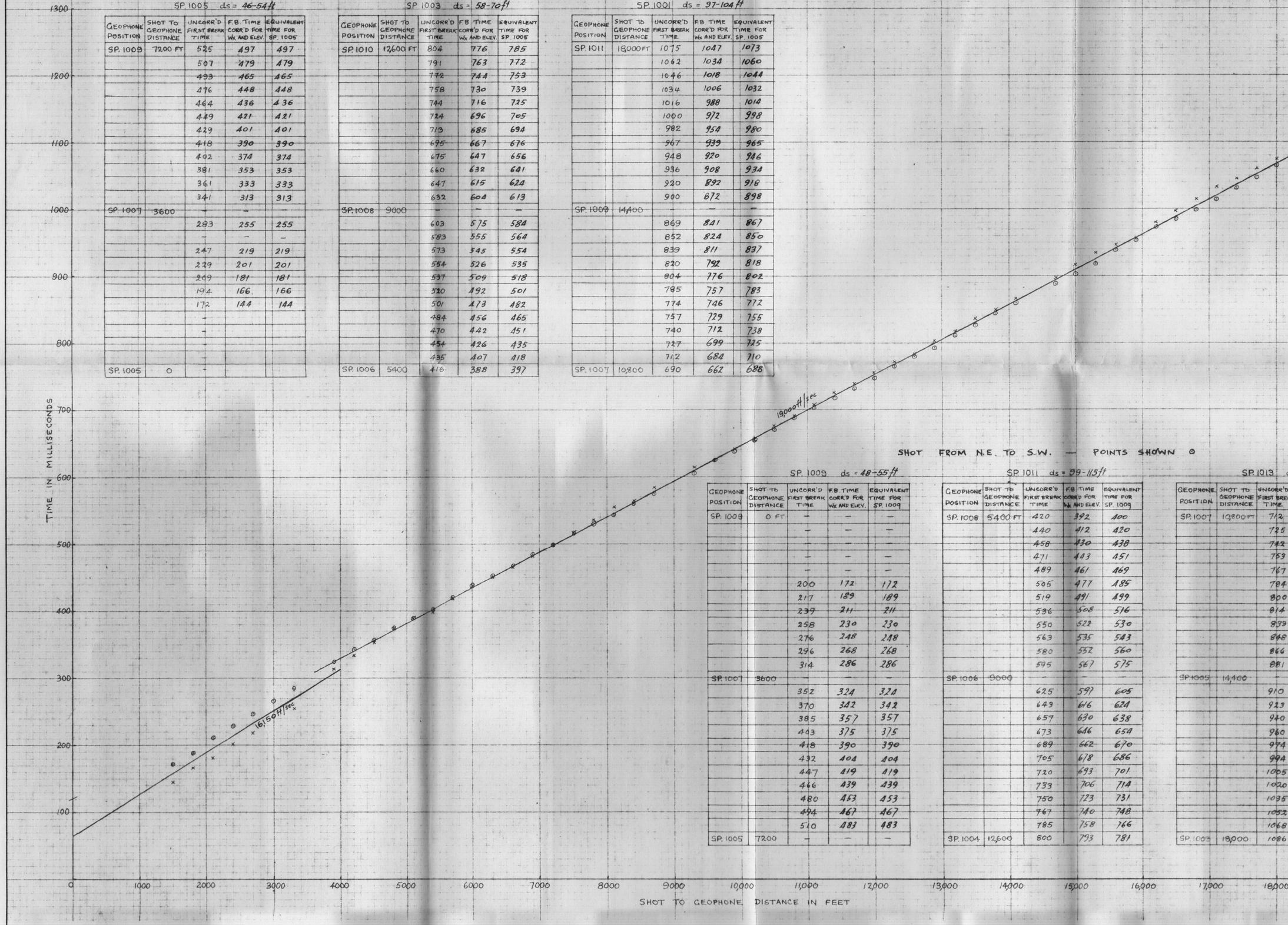
GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/x AND ELEV.	EQUIVALENT TIME FOR SP. 1005
SP. 1009	7200 FT	525	497	497
		507	479	479
		493	465	465
		476	448	448
		464	436	436
		449	421	421
		429	401	401
		418	390	390
		402	374	374
		381	353	353
		361	333	333
		341	313	313
SP. 1007	3600	–	–	–
		283	255	255
		–	–	–
		247	219	219
		229	201	201
		209	181	181
		194	166	166
		172	144	144
		–		
		–		
		–		
		–		
SP. 1005	0	–		

SP. 1003 ds = 58-70 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/x AND ELEV.	EQUIVALENT TIME FOR SP. 1005
SP. 1010	12,600 FT	804	776	785
		791	763	772
		772	744	753
		758	730	739
		744	716	725
		724	696	705
		713	685	694
		695	667	676
		675	647	656
		660	632	641
		647	615	624
		632	604	613
SP. 1008	9000	–	–	–
		603	575	584
		583	555	564
		573	545	554
		554	526	535
		537	509	518
		520	492	501
		501	473	482
		484	456	465
		470	442	451
		454	426	435
		435	407	418
SP. 1006	5400	416	388	397

SP. 1001 ds = 97-104 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/x AND ELEV.	EQUIVALENT TIME FOR SP. 1005
SP. 1011	18000 FT	1075	1047	1073
		1062	1034	1060
		1046	1018	1044
		1034	1006	1032
		1016	988	1014
		1000	972	998
		982	954	980
		967	939	965
		948	920	946
		936	908	934
		920	892	918
		900	672	898
SP. 1009	14,400	–	–	–
		869	841	867
		852	824	850
		839	811	837
		820	792	818
		804	776	802
		785	757	783
		774	746	772
		757	729	755
		740	712	738
		727	699	725
		712	684	710
SP. 1007	10,800	690	662	688



SHOT FROM N.E. TO S.W. — POINTS SHOWN o

SP. 1009 ds = 48-55 ft

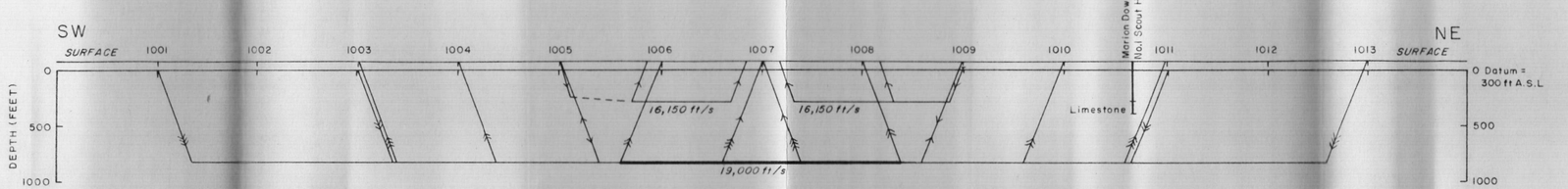
GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/x AND ELEV.	EQUIVALENT TIME FOR SP. 1009
SP. 1008	0 FT	–	–	–
		–	–	–
		–	–	–
		–	–	–
		–	–	–
		200	172	172
		217	189	189
		239	211	211
		258	230	230
		276	248	248
		296	268	268
		314	286	286
SP. 1007	3600	–	–	–
		352	324	324
		370	342	342
		385	357	357
		403	375	375
		418	390	390
		432	404	404
		447	419	419
		466	439	439
		480	453	453
		494	467	467
		510	483	483
SP. 1005	7200	–	–	–

SP. 1011 ds = 99-115 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/x AND ELEV.	EQUIVALENT TIME FOR SP. 1009
SP. 1008	5400 FT	420	392	400
		440	412	420
		458	430	438
		471	443	451
		489	461	469
		505	477	485
		519	491	499
		536	508	516
		550	522	530
		563	535	543
		580	552	560
		595	567	575
SP. 1006	9000	–	–	–
		625	597	605
		643	616	624
		657	630	638
		673	646	654
		689	662	670
		705	678	686
		720	693	701
		733	706	714
		750	723	731
		767	740	748
		785	758	766
SP. 1004	12,600	800	793	781

SP. 1013 ds = 78-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/x AND ELEV.	EQUIVALENT TIME FOR SP. 1009
SP. 1007	10,800 FT	712	684	690
		725	697	703
		742	714	720
		753	725	731
		767	739	745
		784	756	762
		800	772	778
		814	786	792
		833	805	811
		848	821	827
		866	839	845
		881	854	860
SP. 1005	14,400	–	–	–
		910	883	889
		923	896	902
		940	913	919
		960	933	939
		974	947	953
		994	967	973
		1005	978	984
		1020	993	999
		1035	1008	1014
		1052	1025	1031
		1068	1041	1047
SP. 1003	18,000	1086	1059	1065



DIAGRAMMATIC CROSS-SECTION SHOWING POSITIONS OF REFRACTORS AND RAY PATHS VERY APPROXIMATELY



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, 1963-64

TRAVERSE A (MARION DOWNS)

CORRECTED REFRACTION TIME/DISTANCE GRAPH

(Times corrected to datum = 300 feet A.S.L.)

TO ACCOMPANY RECORD No 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS **F54/B3-43-1**

PLATE 7

SHOT FROM W TO E — POINTS SHOWN ×

SHOT FROM E TO W — POINTS SHOWN ⊙

SP. 1103 ds = 73-78 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/H AND ELEV.	EQUIVALENT TIME FOR SP. 1103
SP. 1107	7200 FT	562	533	533
		546	517	517
		530	501	501
		515	486	486
		498	469	469
		482	453	453
		463	434	434
		443	414	414
		422	393	393
		401	372	372
		384	355	355
		366	337	337
SP. 1105	3600	–	–	–
		330	301	301
		309	280	280
		290	262	262
		271	243	243
		249	221	221
		233	205	205
		215	187	187
		198	170	170
		174	146	146
		119	105	105
		68	54	54
SP. 1108	0	–	–	–

SP. 1101 ds = 82-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/H AND ELEV.	EQUIVALENT TIME FOR S.P. 1103
SP. 1108	12600 FT	855	826	827
		841	812	813
		823	794	795
		804	775	776
		789	760	761
		774	745	746
		760	731	732
		743	714	715
		727	698	699
		713	684	685
		697	668	669
		681	652	653
SP. 1106	9000	–	–	–
		645	616	617
		629	600	601
		613	584	585
		598	569	570
		583	554	555
		568	539	540
		549	520	521
		534	505	506
		513	484	485
		495	467	468
		474	446	447
SP. 1104	5400	455	427	428

SP. 1098 ds = 79-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/H AND ELEV.	EQUIVALENT TIME FOR SP. 1103
SP. 1108	18000 FT	1139	1110	1116
		1120	1091	1097
		1102	1073	1079
		1087	1058	1064
		1069	1040	1046
		1058	1029	1035
		1039	1010	1016
		1024	995	1001
		1016	987	993
		995	966	972
		978	949	955
		960	931	937
SP. 1106	14400	–	–	–
		928	899	905
		911	882	888
		895	866	872
		881	852	858
		864	835	841
		851	822	828
		833	804	810
		820	791	797
		800	771	777
		786	758	764
		770	742	748
SP. 1104	10800	752	724	730

SP. 1107 ds = 85-90 ft

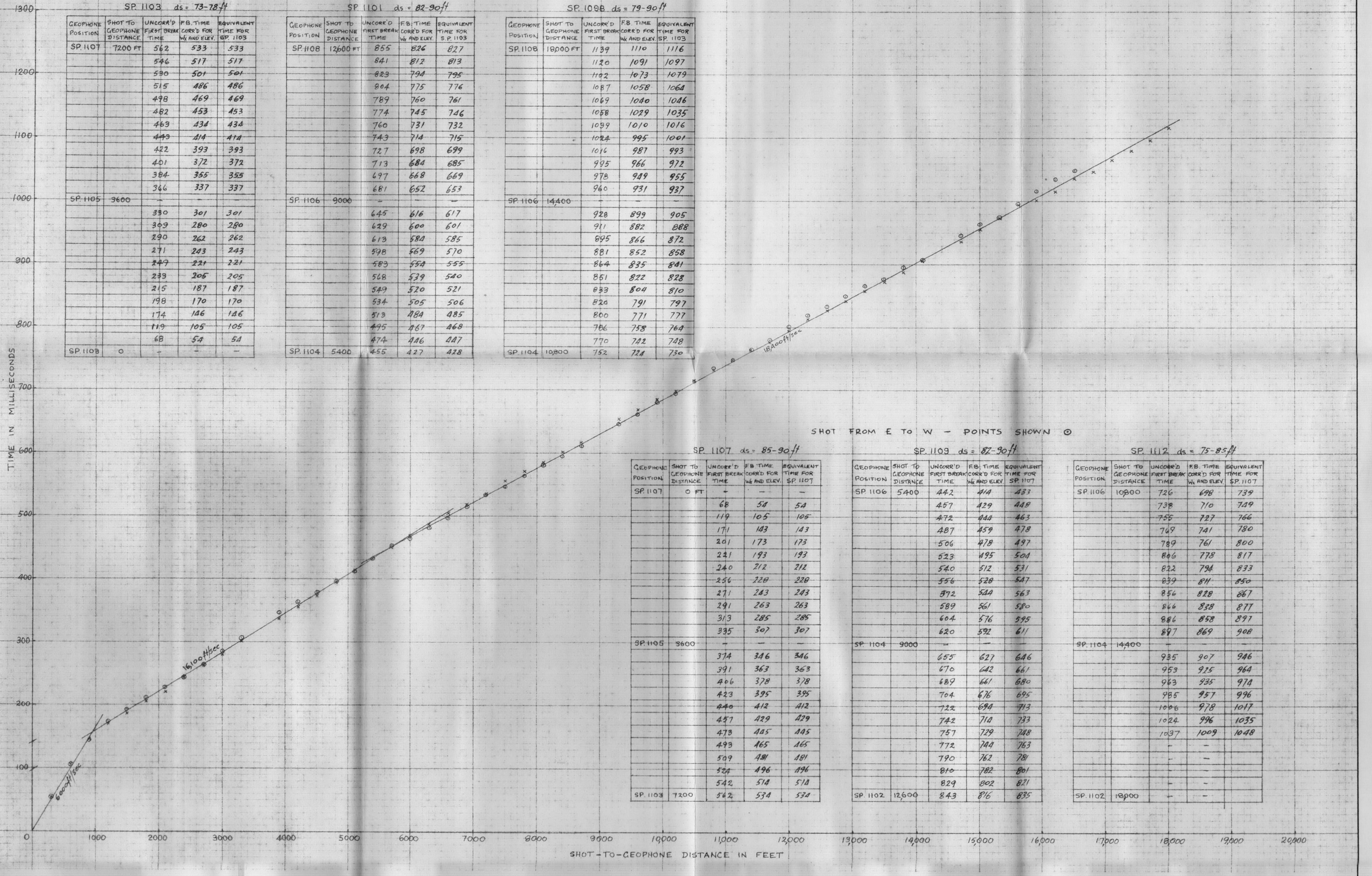
GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/H AND ELEV.	EQUIVALENT TIME FOR SP. 1107
SP. 1107	0 FT	–	–	–
		68	54	54
		119	105	105
		171	143	143
		201	173	173
		221	193	193
		240	212	212
		256	228	228
		271	243	243
		291	263	263
		313	285	285
		335	307	307
SP. 1105	3600	–	–	–
		374	346	346
		391	363	363
		406	378	378
		423	395	395
		440	412	412
		457	429	429
		478	445	445
		493	465	465
		509	481	481
		524	496	496
		542	514	514
SP. 1103	7200	562	534	534

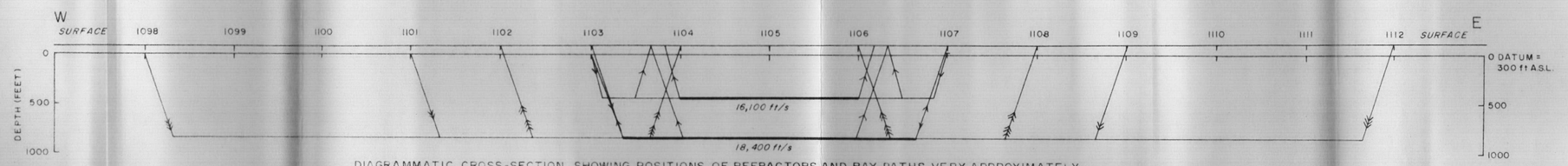
SP. 1109 ds = 82-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/H AND ELEV.	EQUIVALENT TIME FOR SP. 1107
SP. 1106	5400	442	414	433
		457	429	448
		472	444	463
		487	459	478
		506	478	497
		523	495	504
		540	512	531
		556	528	547
		572	544	563
		589	561	580
		604	576	595
		620	592	611
SP. 1104	9000	–	–	–
		655	627	646
		670	642	661
		689	661	680
		704	676	695
		722	694	713
		742	710	733
		757	729	748
		772	744	763
		790	762	781
		810	782	801
		829	802	821
SP. 1102	12600	843	816	835

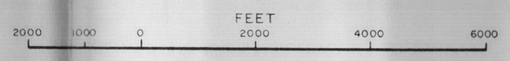
SP. 1112 ds = 75-85 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W/H AND ELEV.	EQUIVALENT TIME FOR SP. 1107
SP. 1106	10800	726	698	739
		738	710	749
		755	727	766
		769	741	780
		789	761	800
		806	778	817
		822	794	833
		839	811	850
		856	828	867
		866	838	877
		886	858	897
		897	869	908
SP. 1104	14400	–	–	–
		935	907	946
		953	925	964
		963	935	974
		985	957	996
		1006	978	1017
		1024	996	1035
		1037	1009	1048
		–	–	
		–	–	
		–	–	
		–	–	
SP. 1102	18000	–	–	





DIAGRAMMATIC CROSS-SECTION SHOWING POSITIONS OF REFRACTORS AND RAY PATHS VERY APPROXIMATELY



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, 1963-64

TRAVERSE B (MARION DOWNS)

CORRECTED REFRACTION TIME/DISTANCE GRAPH

(Times corrected to datum = 300 feet A.S.L.)

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-44-1

SHOT FROM N.W. TO S.E. – POINTS SHOWN ×

SP 1205 ds = 85-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W.D AND ELEV.	EQUIVALENT TIME FOR SP 1205
SP 1209	7200ft	616	586	586
		595	565	565
		578	548	548
		559	529	529
		538	518	518
		519	489	489
		503	473	473
		483	453	453
		462	432	432
		442	412	412
		425	395	395
		405	375	375
SP.1207	3600	–	–	–
		363	333	333
		344	314	314
		323	293	293
		303	273	273
		280	250	250
		259	229	229
		239	209	209
		189	175	175
		136	122	122
		84	70	70
		46	32	32
SP.1205	0	0		

SP 1203 ds = 83-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W.D AND ELEV.	EQUIVALENT TIME FOR SP 1205
SP.1210	12,600ft	942	912	910
		927	897	895
		910	880	878
		892	862	860
		875	845	843
		859	829	827
		840	810	808
		820	790	788
		803	773	771
		784	754	752
		763	733	731
		746	716	714
SP.1208	9000	–	–	–
		710	680	678
		691	661	659
		671	641	639
		655	625	623
		636	606	604
		617	587	585
		598	568	566
		580	550	548
		560	530	528
		543	513	511
		523	493	491
SP.1206	5400	504	474	472

SP 1200 ds = 70-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W.D AND ELEV.	EQUIVALENT TIME FOR SP 1205
SP 1210	18,000ft	1243	1213	1202
		1228	1198	1187
		1211	1181	1170
		1194	1164	1153
		1178	1148	1137
		1161	1131	1120
		1146	1116	1105
		1129	1099	1088
		1111	1081	1070
		1097	1067	1056
		1084	1054	1043
		1070	1040	1029
SP.1208	14,400	–	–	–
		1041	1011	1000
		1027	997	986
		1008	978	967
		992	962	951
		975	945	934
		958	928	917
		939	909	898
		920	890	879
		901	871	860
		883	853	842
		864	834	823
SP.1206	10,800	844	814	803

SP 1197 ds = 75-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W.D AND ELEV.	EQUIVALENT TIME FOR SP 1205
SP.1210	23,400ft	1534	1504	1493
		1525	1495	1484
		1505	1475	1464
		1489	1459	1448
		1470	1440	1429
		1457	1427	1416
		1439	1409	1398
		1421	1391	1380
		1409	1379	1368
		1390	1360	1349
		1373	1343	1332
		1357	1327	1316
SP.1208	19,800	–		–
		1324	1294	1283
		1308	1278	1267
		1293	1263	1252
		1274	1244	1233
		1262	1232	1221
		1244	1214	1203
		1230	1200	1189
		1211	1181	1170
		1197	1167	1156
		1179	1149	1138
		1159	1129	1118
SP.1206	16,200	1143	1113	1102



SHOT FROM S.E. TO N.W. – POINTS SHOWN ⊙

SP 1209 ds = 85-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W.D AND ELEV.	EQUIVALENT TIME FOR SP 1209
SP.1209	0ft	–	–	–
		50	36	36
		93	79	79
		139	125	125
		181	167	167
		232	203	203
		255	226	226
		276	247	247
		296	267	267
		316	287	287
		338	309	309
		359	330	330
SP.1207	3600	–	–	–
		397	368	368
		419	390	390
		438	409	409
		459	430	430
		478	449	449
		499	470	470
		520	491	491
		538	509	509
		556	527	527
		576	547	547
		595	566	566
SP.1205	7200	613	584	584

SP 1211 ds = 82-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W.D AND ELEV.	EQUIVALENT TIME FOR SP1209
SP.1208	5400ft	498	459	473
		547	478	492
		526	497	511
		541	512	526
		562	533	547
		580	551	565
		598	569	583
		615	586	600
		636	607	621
		653	624	638
		674	645	659
		691	662	676
SP.1206	9000	–	–	–
		730	701	715
		747	718	732
		764	735	749
		784	755	769
		800	771	785
		820	791	805
		838	809	823
		855	826	840
		874	845	859
		893	864	878
		910	881	895
SP.1204	12,600	928	899	913

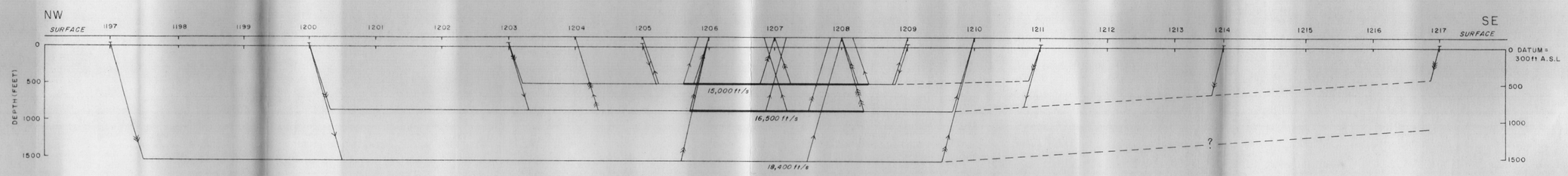
SP 1214* ds = 75-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	F.B. TIME CORR'D FOR W.D AND ELEV.	INTERPOLATED SHOT TO GEO. DISTANCE	EQUIVALENT TIME FOR SP. 1209
SP.1208	10,370ft	732	10,200ft	768
		748		784
		768		802
		786		821
		805		840
		825		859
		842		878
		862		896
		879		915
		895		931
		916		950
		934		969
SP.1206	13,970	–	13,800	–
		972		1007
		990		1025
		1006		1038
		1024		1059
		1042		1077
		1062		1096
		1079		1115
		1096		1132
		1115		1150
		1135		1169
		1152		1188
SP.1204	17,570	1168	17,400	1204

* SP 1214 IS ONLY 1370' FROM SP 1213

SP 1217 ds = 75-90 ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W.D AND ELEV.	EQUIVALENT TIME FOR SP. 1209
SP.1208	16,200ft	1095	1066	1133
		1113	1084	1151
		1132	1103	1170
		1148	1119	1186
		1166	1137	1204
		1186	1157	1224
		1204	1175	1242
		1220	1191	1258
		1242	1213	1280
		1257	1228	1295
		1279	1248	1315
		1296	1267	1334
SP.1206	19,800	–	–	–
		1334	1305	1372
		1353	1324	1391
		1368	1339	1406
		1385	1356	1423
		1404	1375	1442
		1424	1395	1462
		1439	1410	1477
		1459	1428	1495
		1477	1448	1515
		1494	1465	1532
		1513	1484	1551
SP.1204	23,400	1531	1502	1569



DIAGRAMMATIC CROSS-SECTION SHOWING POSITIONS OF REFRACTORS AND RAY PATHS VERY APPROXIMATELY

FEET
2000 1000 0 2000 4000 6000

SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, 1963-64

TRAVERSE C (LORNA DOWNS)

CORRECTED REFRACTION TIME/DISTANCE GRAPH

(Times corrected to datum = 300 feet A.S.L.)

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-45-1

SHOT FROM W TO E — POINTS SHOWN ×

SP 1305 ds = 85-90ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W. AND ELEV.	EQUIVALENT TIME FOR SP 1305
SP 1309	7200ft	648	604	604
		628	584	584
		606	562	562
		586	542	542
		565	521	521
		543	499	499
		523	479	479
		501	457	457
		478	434	434
		456	412	412
		436	392	392
		415	371	371
SP 1307	3600	—	—	—
		374	330	330
		353	309	309
		330	286	286
		307	263	263
		287	243	243
		265	221	221
		225	183	183
		187	173	173
		112	98	98
		80	66	66
		47	33	33
SP 1305	0	—	—	—

SP 1303 ds = 80-90ft

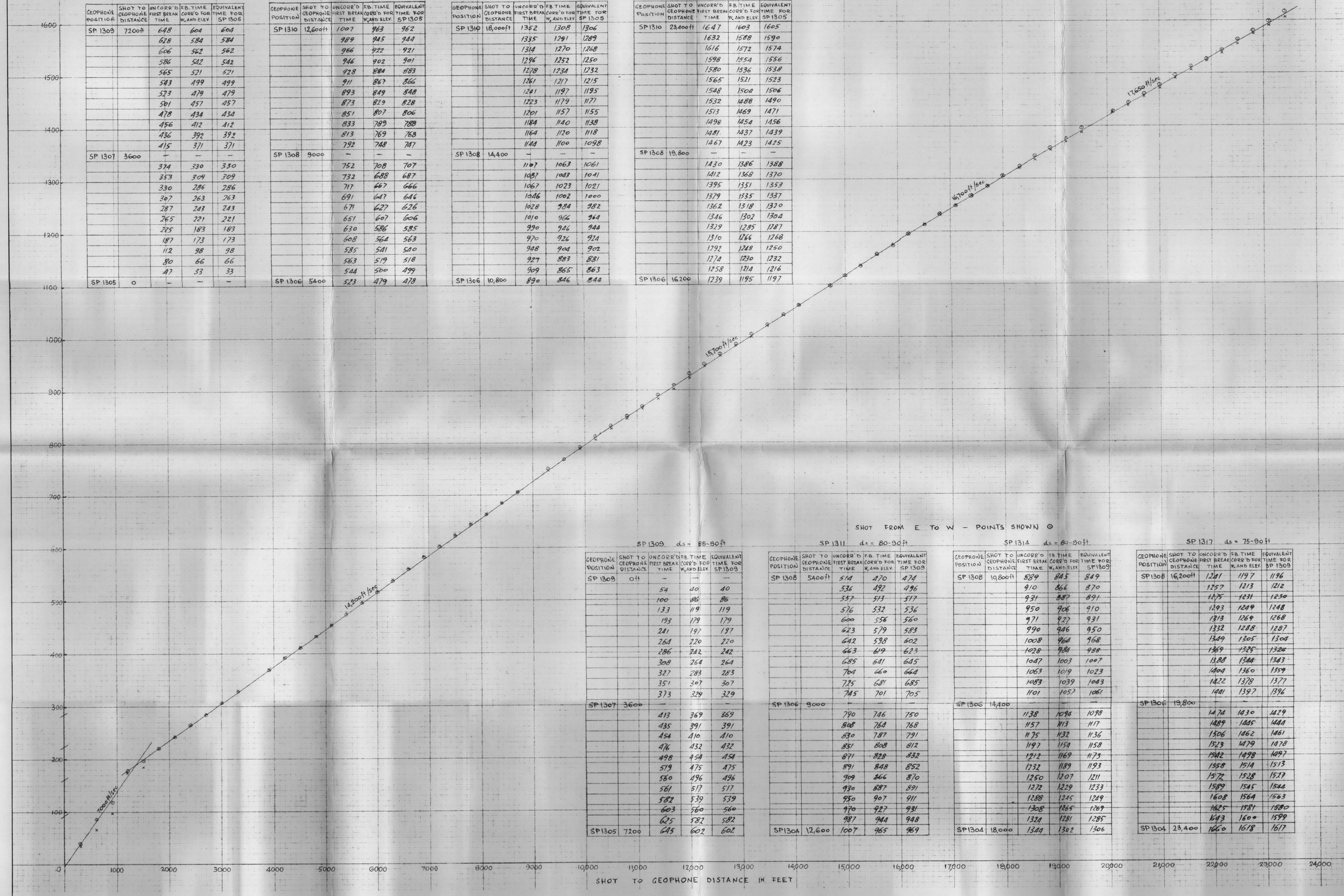
GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W. AND ELEV.	EQUIVALENT TIME FOR SP 1305
SP 1310	12,600ft	1007	963	962
		989	945	944
		966	922	921
		946	902	901
		928	884	883
		911	867	866
		893	849	848
		873	829	828
		851	807	806
		833	789	788
		813	769	768
		792	748	747
SP 1308	9000	—	—	—
		752	708	707
		732	688	687
		717	667	666
		691	647	646
		671	627	626
		651	607	606
		630	586	585
		608	564	563
		585	541	540
		563	519	518
		544	500	499
SP 1306	5400	523	479	478

SP 1300 ds = 80-90ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W. AND ELEV.	EQUIVALENT TIME FOR SP 1305
SP 1310	18,000ft	1352	1308	1306
		1335	1291	1289
		1314	1270	1268
		1296	1252	1250
		1278	1234	1232
		1261	1217	1215
		1241	1197	1195
		1223	1179	1177
		1201	1157	1155
		1184	1140	1138
		1164	1120	1118
		1144	1100	1098
SP 1308	14,400	—	—	—
		1107	1063	1061
		1087	1043	1041
		1067	1023	1021
		1046	1002	1000
		1028	984	982
		1010	966	964
		990	946	944
		970	926	924
		948	904	902
		927	883	881
		909	865	863
SP 1306	10,800	890	846	844

SP 1297 ds = 75-90ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W. AND ELEV.	EQUIVALENT TIME FOR SP 1305
SP 1310	23,400ft	1647	1603	1605
		1632	1588	1590
		1616	1572	1574
		1598	1554	1556
		1580	1536	1538
		1565	1521	1523
		1548	1504	1506
		1532	1488	1490
		1513	1469	1471
		1498	1454	1456
		1481	1437	1439
		1467	1423	1425
SP 1308	19,800	—	—	—
		1430	1386	1388
		1412	1368	1370
		1395	1351	1353
		1379	1335	1337
		1362	1318	1320
		1346	1302	1304
		1329	1285	1287
		1310	1266	1268
		1792	1248	1250
		1274	1230	1232
		1258	1214	1216
SP 1306	16200	1239	1195	1197



SHOT FROM E TO W — POINTS SHOWN ⊙

SP 1309 ds = 85-90ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W. AND ELEV.	EQUIVALENT TIME FOR SP 1309
SP 1309	0ft	—	—	—
		54	40	40
		100	86	86
		133	119	119
		193	179	179
		241	197	197
		264	220	220
		286	242	242
		308	264	264
		327	283	283
		351	307	307
		373	329	329
SP 1307	3600	—	—	—
		413	369	369
		435	391	391
		454	410	410
		476	432	432
		498	454	454
		519	475	475
		560	496	496
		561	517	517
		582	539	539
		603	560	560
		625	582	582
SP1305	7200	645	602	602

SP 1311 ds = 80-90ft

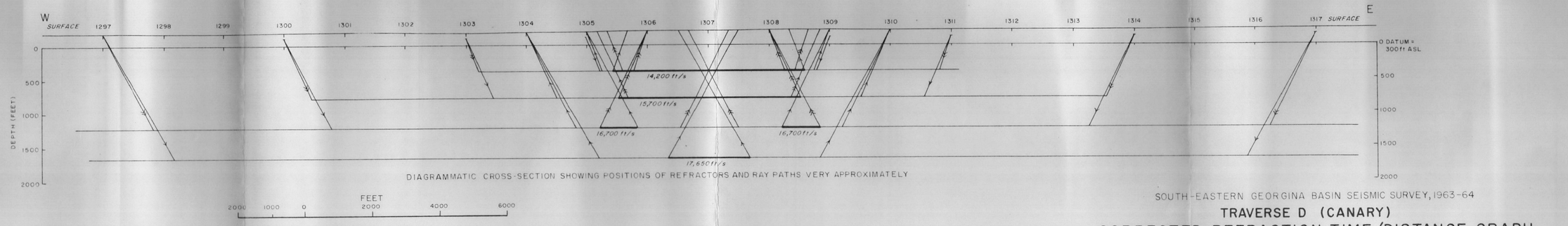
GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W. AND ELEV.	EQUIVALENT TIME FOR SP 1309
SP 1308	540oft	514	470	474
		536	492	496
		557	513	517
		576	532	536
		600	556	560
		623	579	583
		642	598	602
		663	619	623
		685	641	645
		704	660	664
		725	681	685
		745	701	705
SP 1306	9000	—	—	—
		790	746	750
		808	764	768
		830	787	791
		851	808	812
		871	828	832
		891	848	852
		909	866	870
		930	887	891
		950	907	911
		970	927	931
		987	944	948
SP1304	12,600	1007	965	969

SP 1314 ds = 80-90ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W. AND ELEV.	EQUIVALENT TIME FOR SP 1309
SP 1308	10,800ft	889	845	849
		910	866	870
		931	887	891
		950	906	910
		971	927	931
		990	946	950
		1008	964	968
		1028	984	988
		1047	1003	1007
		1063	1019	1023
		1083	1039	1043
		1101	1057	1061
SP 1306	14,400	—	—	—
		1138	1094	1098
		1157	1113	1117
		1175	1132	1136
		1197	1158	1158
		1212	1169	1173
		1232	1189	1193
		1250	1207	1211
		1272	1229	1233
		1288	1245	1249
		1308	1265	1269
		1324	1281	1285
SP1304	18,000	1344	1302	1306

SP 1317 ds = 75-90ft

GEOPHONE POSITION	SHOT TO GEOPHONE DISTANCE	UNCORR'D FIRST BREAK TIME	F.B. TIME CORR'D FOR W. AND ELEV.	EQUIVALENT TIME FOR SP 1309
SP 1308	16,200ft	1241	1197	1196
		1257	1213	1212
		1275	1231	1230
		1293	1249	1248
		1313	1269	1268
		1332	1288	1287
		1349	1305	1304
		1369	1325	1324
		1388	1344	1343
		1400	1360	1359
		1422	1378	1377
		1441	1397	1396
SP 1306	19,800	—	—	—
		1470	1430	1429
		1489	1445	1444
		1506	1462	1461
		1523	1479	1478
		1542	1498	1497
		1558	1514	1513
		1572	1528	1527
		1589	1545	1544
		1608	1564	1563
		1625	1581	1580
		1643	1600	1599
SP 1304	23,400	1660	1618	1617



DIAGRAMMATIC CROSS-SECTION SHOWING POSITIONS OF REFRACTORS AND RAY PATHS VERY APPROXIMATELY

SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, 1963-64

TRAVERSE D (CANARY)

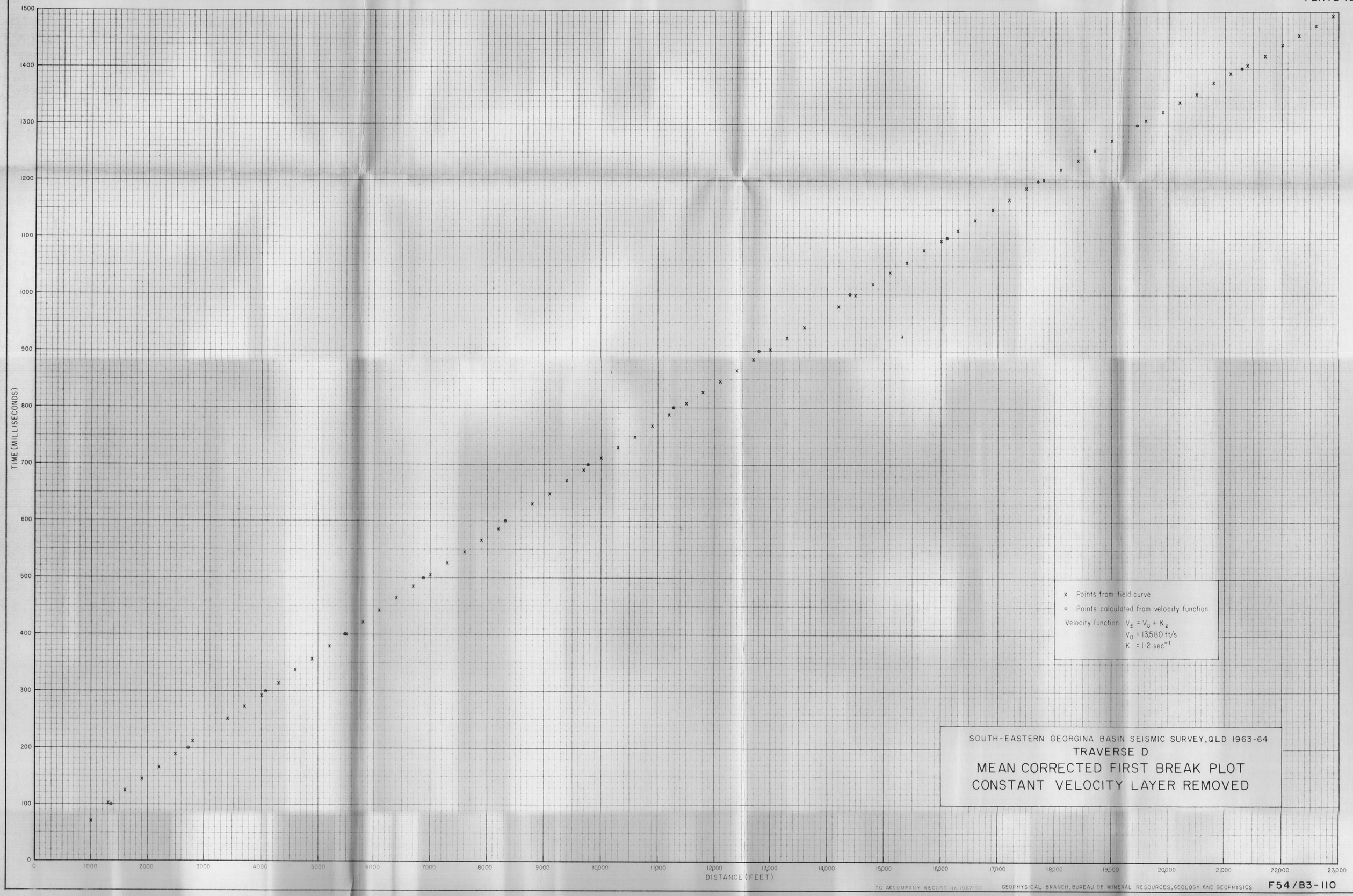
CORRECTED REFRACTION TIME/DISTANCE GRAPH

(Times corrected to datum = 300 feet A.S.L.)

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-46-1

PLATE 10



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963-64

TRAVERSE D

MEAN CORRECTED FIRST BREAK PLOT CONSTANT VELOCITY LAYER REMOVED

TO ACCOMPANY RECORD No. 1967/90 GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-110

SP 7647 ds = 39'/45'

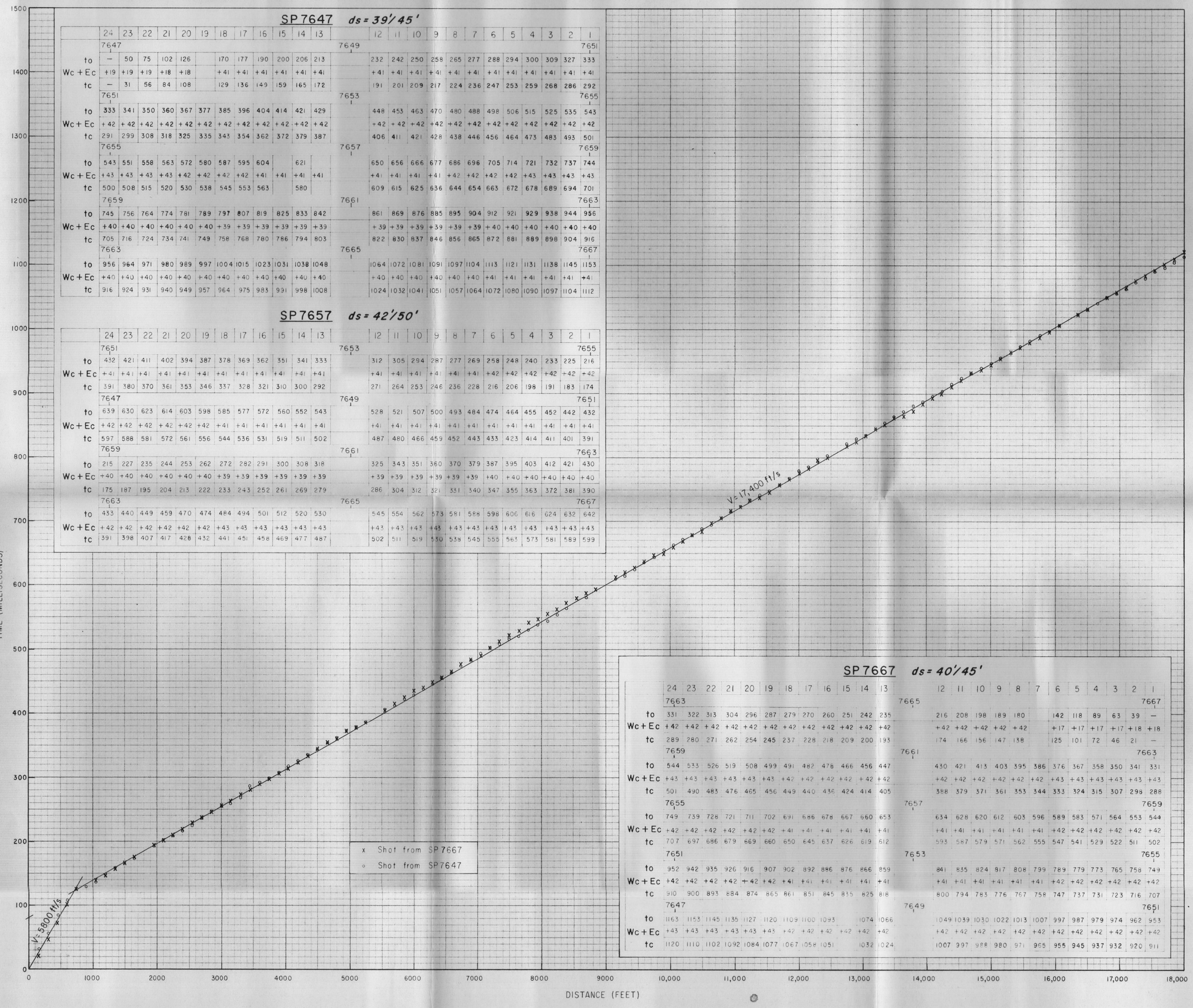
	24	23	22	21	20	19	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1
	7647												7649												7651
to	–	50	75	102	126		170	177	190	200	206	213		232	242	250	258	265	277	288	294	300	309	327	333
Wc + Ec	+19	+19	+19	+18	+18		+41	+41	+41	+41	+41	+41		+41	+41	+41	+41	+41	+41	+41	+41	+41	+41	+41	+41
tc	–	31	56	84	108		129	136	149	159	165	172		191	201	209	217	224	236	247	253	259	268	286	292
	7651												7653												7655
to	333	341	350	360	367	377	385	396	404	414	421	429		448	453	463	470	480	488	498	506	515	525	535	543
Wc + Ec	+42	+42	+42	+42	+42	+42	+42	+42	+42	+42	+42	+42		+42	+42	+42	+42	+42	+42	+42	+42	+42	+42	+42	+42
tc	291	299	308	318	325	335	343	354	362	372	379	387		406	411	421	428	438	446	456	464	473	483	493	501
	7655												7657												7659
to	543	551	558	563	572	580	587	595	604		621			650	656	666	677	686	696	705	714	721	732	737	744
Wc + Ec	+43	+43	+43	+43	+42	+42	+42	+42	+41	+41	+41	+41		+41	+41	+41	+41	+42	+42	+42	+42	+43	+43	+43	+43
tc	500	508	515	520	530	538	545	553	563		580			609	615	625	636	644	654	663	672	678	689	694	701
	7659												7661												7663
to	745	756	764	774	781	789	797	807	819	825	833	842		861	869	876	885	895	904	912	921	929	938	944	956
Wc + Ec	+40	+40	+40	+40	+40	+40	+39	+39	+39	+39	+39	+39		+39	+39	+39	+39	+39	+39	+40	+40	+40	+40	+40	+40
tc	705	716	724	734	741	749	758	768	780	786	794	803		822	830	837	846	856	865	872	881	889	898	904	916
	7663												7665												7667
to	956	964	971	980	989	997	1004	1015	1023	1031	1038	1048		1064	1072	1081	1091	1097	1104	1113	1121	1131	1138	1145	1153
Wc + Ec	+40	+40	+40	+40	+40	+40	+40	+40	+40	+40	+40	+40		+40	+40	+40	+40	+40	+40	+41	+41	+41	+41	+41	+41
tc	916	924	931	940	949	957	964	975	983	931	998	1008		1024	1032	1041	1051	1057	1064	1072	1080	1090	1097	1104	1112

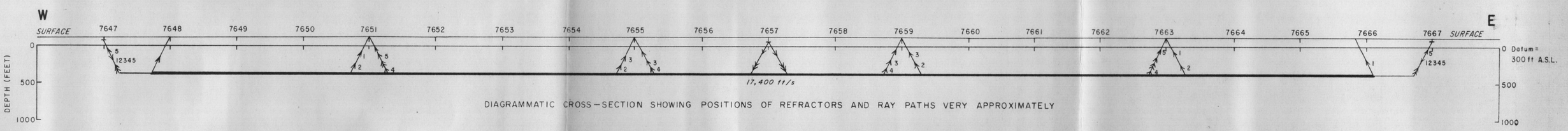
SP 7657 ds = 42'/50'

	24	23	22	21	20	19	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1
	7651												7653												7655
to	432	421	411	402	394	387	378	369	362	351	341	333		312	305	294	287	277	269	258	248	240	233	225	216
Wc + Ec	+41	+41	+41	+41	+41	+41	+41	+41	+41	+41	+41	+41		+41	+41	+41	+41	+41	+41	+42	+42	+42	+42	+42	+42
tc	391	380	370	361	353	346	337	328	321	310	300	292		271	264	253	246	236	228	216	206	198	191	183	174
	7647												7649												7651
to	639	630	623	614	603	598	585	577	572	560	552	543		528	521	507	500	493	484	474	464	455	452	442	432
Wc + Ec	+42	+42	+42	+42	+42	+42	+41	+41	+41	+41	+41	+41		+41	+41	+41	+41	+41	+41	+41	+41	+41	+41	+41	+41
tc	597	588	581	572	561	556	544	536	531	519	511	502		487	480	466	459	452	443	433	423	414	411	401	391
	7659												7661												7663
to	215	227	235	244	253	262	272	282	291	300	308	318		325	343	351	360	370	379	387	395	403	412	421	430
Wc + Ec	+40	+40	+40	+40	+40	+40	+39	+39	+39	+39	+39	+39		+39	+39	+39	+39	+39	+39	+40	+40	+40	+40	+40	+40
tc	175	187	195	204	213	222	233	243	252	261	269	279		286	304	312	321	331	340	347	355	363	372	381	390
	7663												7665												7667
to	433	440	449	459	470	474	484	494	501	512	520	530		545	554	562	573	581	588	598	606	616	624	632	642
Wc + Ec	+42	+42	+42	+42	+42	+42	+43	+43	+43	+43	+43	+43		+43	+43	+43	+43	+43	+43	+43	+43	+43	+43	+43	+43
tc	391	398	407	417	428	432	441	451	458	469	477	487		502	511	519	530	538	545	555	563	573	581	589	599

SP 7667 ds = 40'/45'

	24	23	22	21	20	19	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1
	7663												7665												7667
to	331	322	313	304	296	287	279	270	260	251	242	235		216	208	198	189	180		142	118	89	63	39	–
Wc + Ec	+42	+42	+42	+42	+42	+42	+42	+42	+42	+42	+42	+42		+42	+42	+42	+42	+42		+17	+17	+17	+17	+18	+18
tc	289	280	271	262	254	245	237	228	218	209	200	193		174	166	156	147	138		125	101	72	46	21	–
	7659												7661												7663
to	544	533	526	519	508	499	491	482	476	466	456	447		430	421	413	403	395	386	376	367	358	350	341	331
Wc + Ec	+43	+43	+43	+43	+43	+43	+42	+42	+42	+42	+42	+42		+42	+42	+42	+42	+42	+42	+43	+43	+43	+43	+43	+43
tc	501	490	483	476	465	456	449	440	436	424	414	405		388	379	371	361	353	344	333	324	315	307	298	288
	7655												7657												7659
to	749	739	728	721	711	702	691	686	678	667	660	653		634	628	620	612	603	596	589	583	571	564	553	544
Wc + Ec	+42	+42	+42	+42	+42	+42	+41	+41	+41	+41	+41	+41		+41	+41	+41	+41	+41	+41	+42	+42	+42	+42	+42	+42
tc	707	697	686	679	669	660	650	645	637	626	619	612		593	587	579	571	562	555	547	541	529	522	511	502
	7651												7653												7655
to	952	942	935	926	916	907	902	892	886	876	866	859		841	835	824	817	808	799	789	779	773	765	758	749
Wc + Ec	+42	+42	+42	+42	+42	+42	+41	+41	+41	+41	+41	+41		+41	+41	+41	+41	+41	+41	+42	+42	+42	+42	+42	+42
tc	910	900	893	884	874	865	861	851	845	835	825	818		800	794	783	776	767	758	747	737	731	723	716	707
	7647												7649												7651
to	1163	1153	1145	1135	1127	1120	1109	1100	1093		1074	1066		1049	1039	1030	1022	1013	1007	997	987	979	974	962	953
Wc + Ec	+43	+43	+43	+43	+43	+43	+42	+42	+42	+42	+42	+42		+42	+42	+42	+42	+42	+42	+42	+42	+42	+42	+42	+42
tc	1120	1110	1102	1092	1084	1077	1067	1058	1051		1032	1024		1007	997	988	980	971	965	955	945	937	932	920	911





DIAGRAMMATIC CROSS-SECTION SHOWING POSITIONS OF REFRACTORS AND RAY PATHS VERY APPROXIMATELY

FEET
1000 500 0 1000 2000 3000

SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963-64

TRAVERSE V_1 (LORNA DOWNS)

CORRECTED REFRACTION TIME/DISTANCE GRAPH

(Times corrected to datum - 300 feet A.S.L.)

TO ACCOMPANY RECORD No. 1967/90

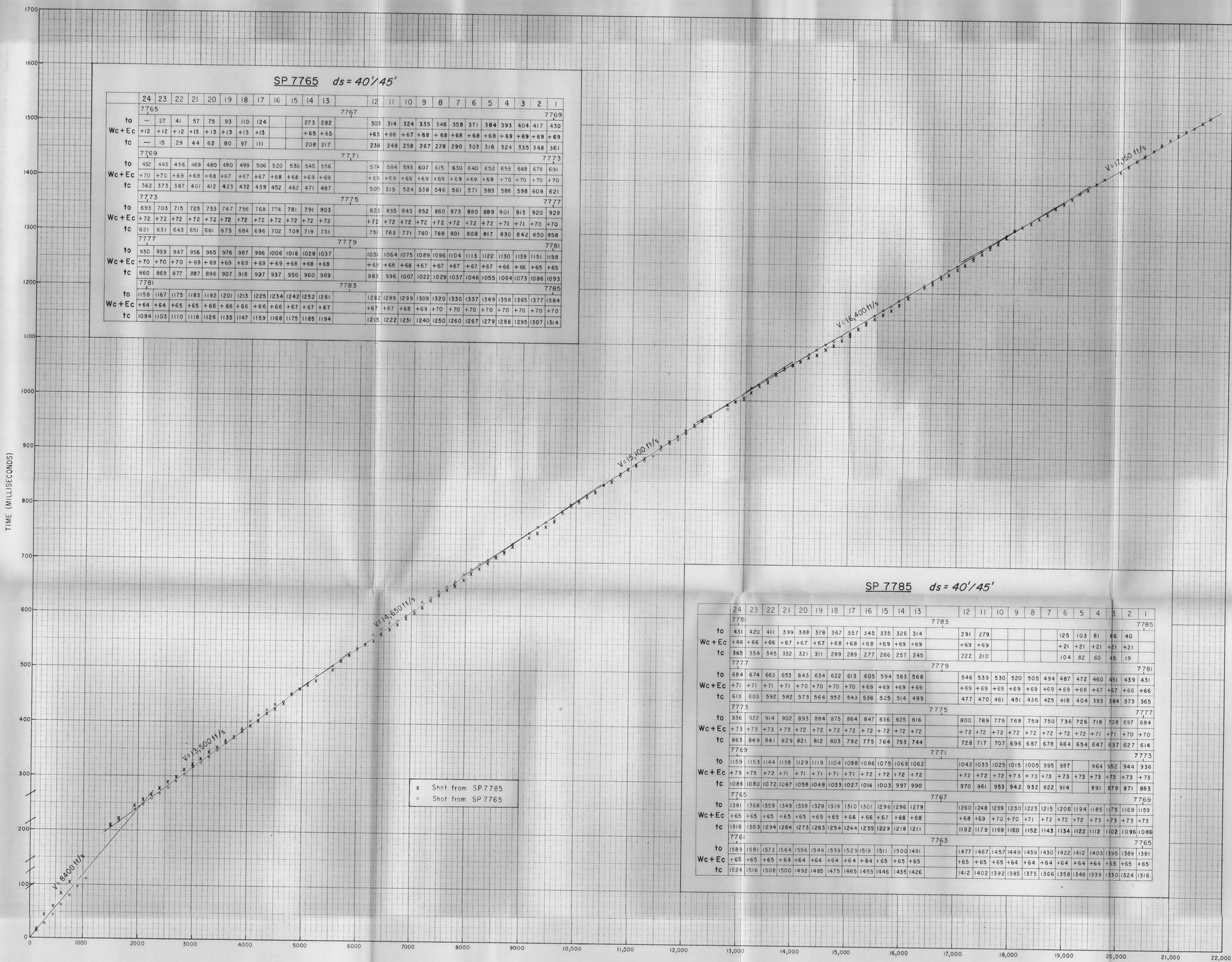
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-108

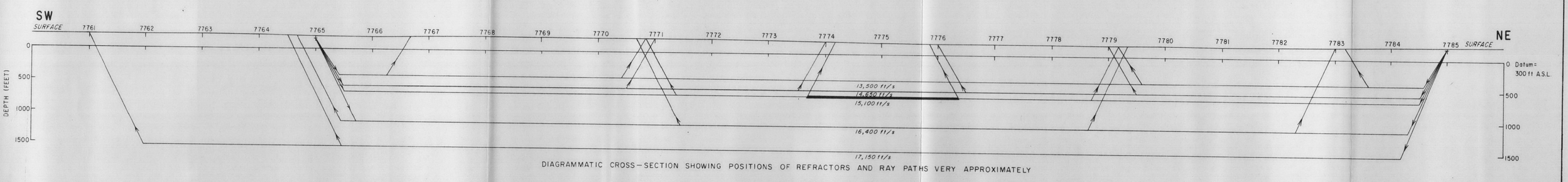
SP 7765 ds = 40'/45'

	24	23	22	21	20	19	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1
	7765												7767												7769
to	—	27	41	57	75	93	110	124			273	282		303	314	324	335	346	358	371	384	393	404	417	430
Wc+Ec	+12	+12	+12	+13	+13	+13	+13	+13			+65	+65		+65	+66	+67	+68	+68	+68	+68	+68	+69	+69	+69	+69
tc	—	15	29	44	62	80	97	111			208	217		238	248	258	267	278	290	303	316	324	335	348	361
	7769												7771												7773
to	432	443	456	469	480	490	499	506	520	530	540	556		574	584	593	607	615	630	640	652	658	668	678	691
Wc+Ec	+70	+70	+69	+68	+68	+67	+67	+67	+68	+68	+69	+69		+69	+69	+69	+69	+69	+69	+69	+69	+70	+70	+70	+70
tc	362	373	387	401	412	423	432	439	452	462	471	487		505	515	524	538	546	561	571	583	588	598	608	621
	7773												7775												7777
to	693	703	715	725	733	747	756	768	774	781	791	803		823	835	843	852	860	873	880	889	901	913	920	928
Wc+Ec	+72	+72	+72	+72	+72	+72	+72	+72	+72	+72	+72	+72		+72	+72	+72	+72	+72	+72	+72	+72	+71	+71	+70	+70
tc	621	631	643	651	661	675	684	696	702	709	719	731		751	763	771	780	788	801	808	817	830	842	850	858
	7777												7779												7781
to	930	939	947	956	965	976	987	996	1006	1018	1028	1037		1051	1064	1075	1089	1096	1104	1113	1122	1130	1139	1151	1158
Wc+Ec	+70	+70	+70	+69	+69	+69	+69	+69	+69	+68	+68	+68		+68	+68	+68	+67	+67	+67	+67	+67	+66	+66	+65	+65
tc	860	869	877	887	896	907	918	927	937	950	960	969		983	996	1007	1022	1029	1037	1046	1055	1064	1073	1086	1093
	7781												7783												7785
to	1158	1167	1175	1183	1192	1201	1213	1225	1234	1242	1252	1261		1282	1289	1299	1309	1320	1330	1337	1349	1358	1365	1377	1384
Wc+Ec	+64	+64	+65	+65	+66	+66	+66	+66	+66	+67	+67	+67		+67	+67	+68	+69	+70	+70	+70	+70	+70	+70	+70	+70
tc	1094	1103	1110	1118	1126	1135	1147	1159	1168	1175	1185	1194		1215	1222	1231	1240	1250	1260	1267	1279	1288	1295	1307	1314

SP 7785 ds = 40'/45'

	24	23	22	21	20	19	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1
	7781												7783												7785
to	431	420	411	399	388	378	367	357	345	335	326	314		291	279					125	103	81	66	40	
Wc+Ec	+66	+66	+66	+67	+67	+67	+68	+68	+68	+69	+69	+69		+69	+69					+21	+21	+21	+21	+21	
tc	365	354	345	332	321	311	299	289	277	266	257	245		222	210					104	82	60	45	19	
	7777												7779												7781
to	684	674	663	653	643	634	622	613	605	594	583	568		546	539	530	520	505	494	487	472	460	451	439	431
Wc+Ec	+71	+71	+71	+71	+70	+70	+70	+70	+69	+69	+69	+69		+69	+69	+69	+69	+69	+69	+69	+68	+67	+67	+66	+66
tc	613	603	592	582	573	564	552	543	536	525	514	499		477	470	461	451	436	425	418	404	393	384	373	365
	7773												7775												7777
to	936	922	914	902	893	884	875	864	847	836	825	816		800	789	779	768	759	750	736	726	718	708	697	684
Wc+Ec	+73	+73	+73	+73	+72	+72	+72	+72	+72	+72	+72	+72		+72	+72	+72	+72	+72	+72	+72	+72	+71	+71	+70	+70
tc	863	849	841	829	821	812	803	792	775	764	753	744		728	717	707	696	687	678	664	654	647	637	627	614
	7769												7771												7773
to	1159	1153	1144	1138	1129	1119	1104	1098	1086	1075	1069	1062		1042	1033	1025	1015	1005	995	987		964	952	944	936
Wc+Ec	+73	+73	+72	+71	+71	+71	+71	+71	+72	+72	+72	+72		+72	+72	+72	+73	+73	+73	+73	+73	+73	+73	+73	+73
tc	1086	1080	1072	1067	1058	1048	1033	1027	1014	1003	997	990		970	961	953	942	932	922	914		891	879	871	863
	7765												7767												7769
to	1381	1368	1359	1349	1338	1328	1319	1310	1301	1296	1286	1279		1260	1248	1239	1230	1223	1215	1206	1194	1185	1175	1169	1159
Wc+Ec	+65	+65	+65	+65	+65	+65	+65	+66	+66	+67	+68	+68		+68	+69	+70	+70	+71	+72	+72	+72	+73	+73	+73	+73
tc	1316	1303	1294	1284	1273	1263	1254	1244	1235	1229	1218	1211		1192	1179	1169	1160	1152	1143	1134	1122	1112	1102	1096	1086
	7761												7763												7765
to	1589	1581	1573	1564	1556	1549	1539	1529	1519	1511	1500	1491		1477	1467	1457	1449	1439	1430	1422	1412	1403	1395	1389	1381
Wc+Ec	+65	+65	+65	+64	+64	+64	+64	+64	+64	+65	+65	+65		+65	+65	+65	+64	+64	+64	+64	+64	+64	+65	+65	+65
tc	1524	1516	1508	1500	1492	1485	1475	1465	1455	1446	1435	1426		1412	1402	1392	1385	1375	1366	1358	1348	1339	1330	1324	1316





DIAGRAMMATIC CROSS-SECTION SHOWING POSITIONS OF REFRACTORS AND RAY PATHS VERY APPROXIMATELY

FEET 1000 500 0 1000 2000 3000

SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963-64

TRAVERSE V_2 (CANARY)

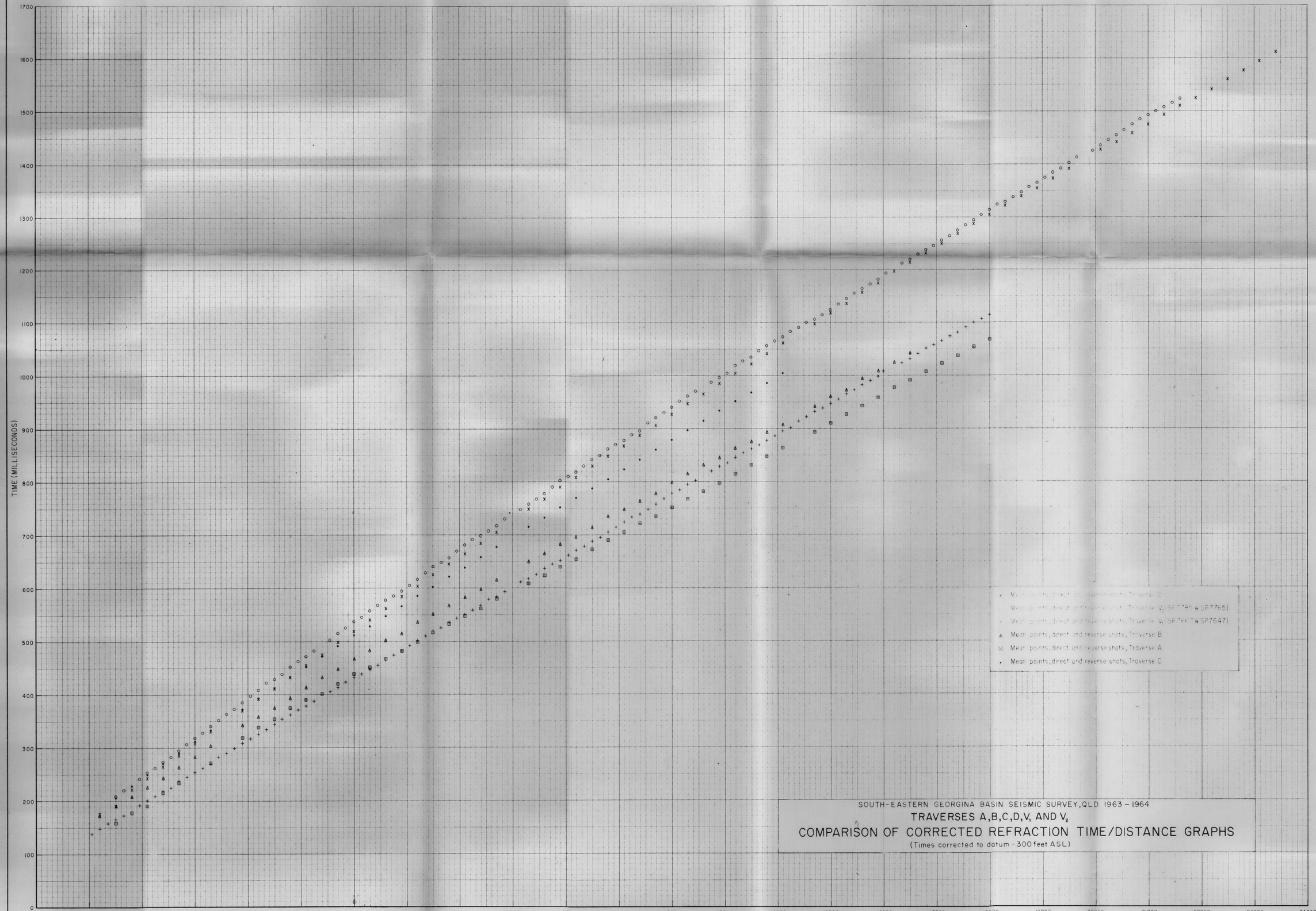
CORRECTED REFRACTION TIME/DISTANCE GRAPH

(Times corrected to datum - 300 feet A.S.L.)

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-109

PLATE 13



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963 – 1964

TRAVERSES A, B, C, D, V_1 AND V_2

COMPARISON OF CORRECTED REFRACTION TIME/DISTANCE GRAPHS

(Times corrected to datum – 300 feet ASL)

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-107

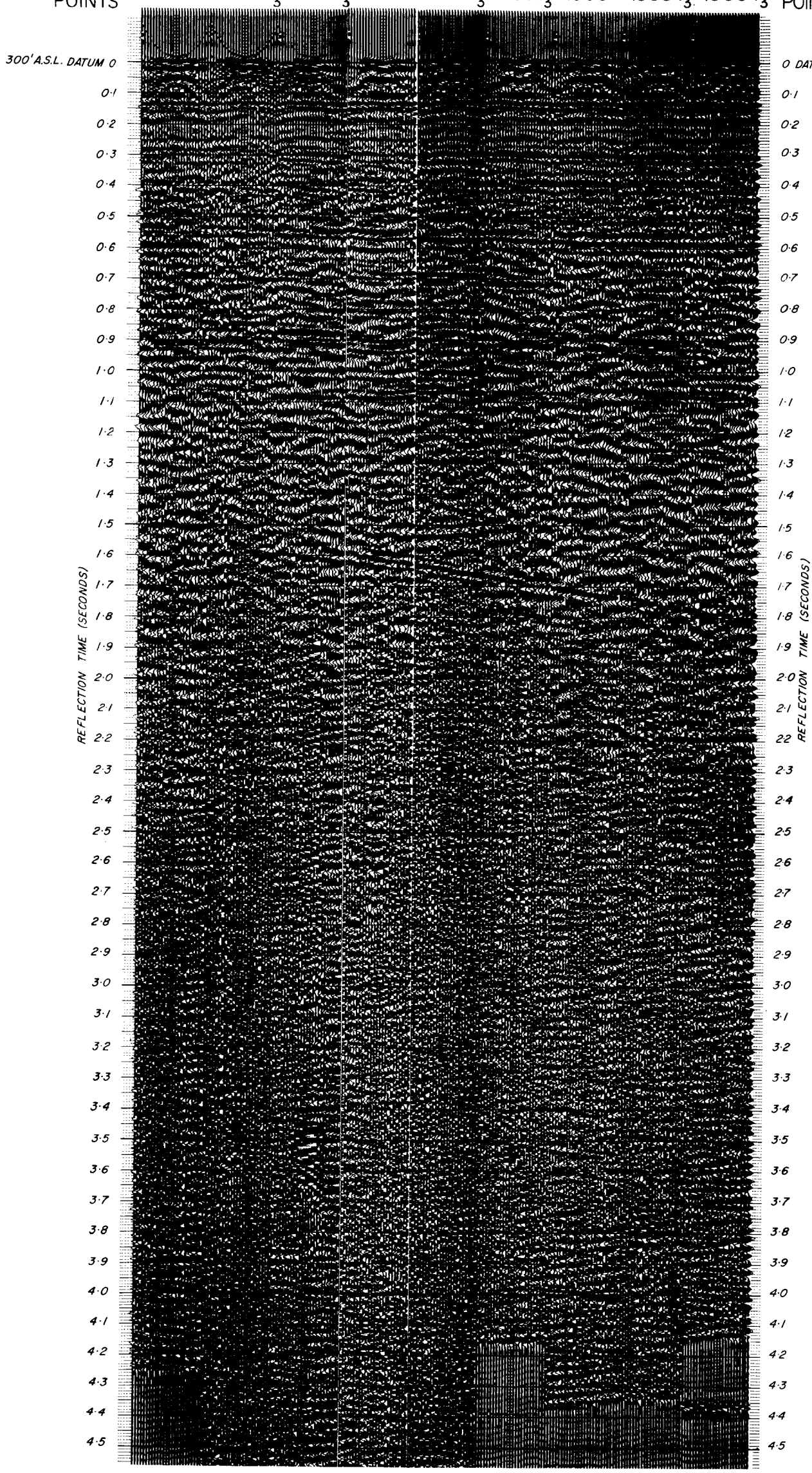


PLATE 14

CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7 – 7

Amplifiers : 7000 B

Filters : K18 – K160

A.G.C. : W.B.

Gain Initial : –60

Final : –10

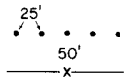
Geophones : HSJ – 14 c/s

Geophone pattern :

16/trace, 20' apart in line

Station interval 50'

Shot-hole pattern :



Depth 60'

Charge 5 x 1¼ lb

PLAYBACK INFORMATION

Filters : 1/20 – 1/78

A.G.C. : S.

Gain Initial : –50

Final : –20

Trip delay : 0

Compositing : Nil

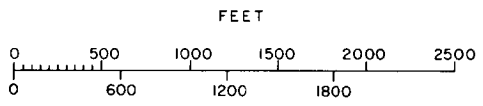
VELOCITY INFORMATION

Sonic log

Canary No1 Bore SP 1307

and t:Δt analysis

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1963

TRAVERSE D

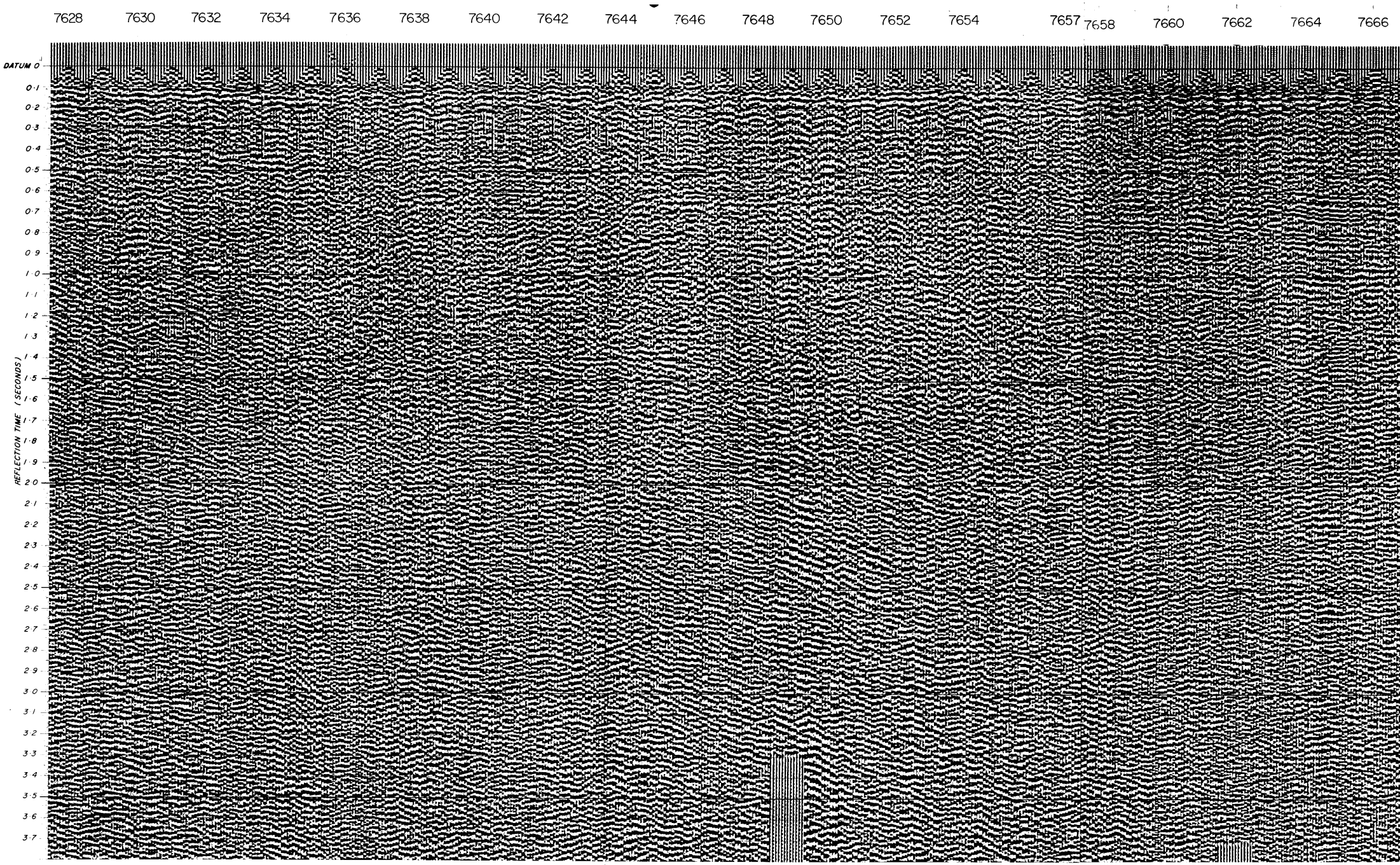
RECORDED BY : *Seismic Party No.1*

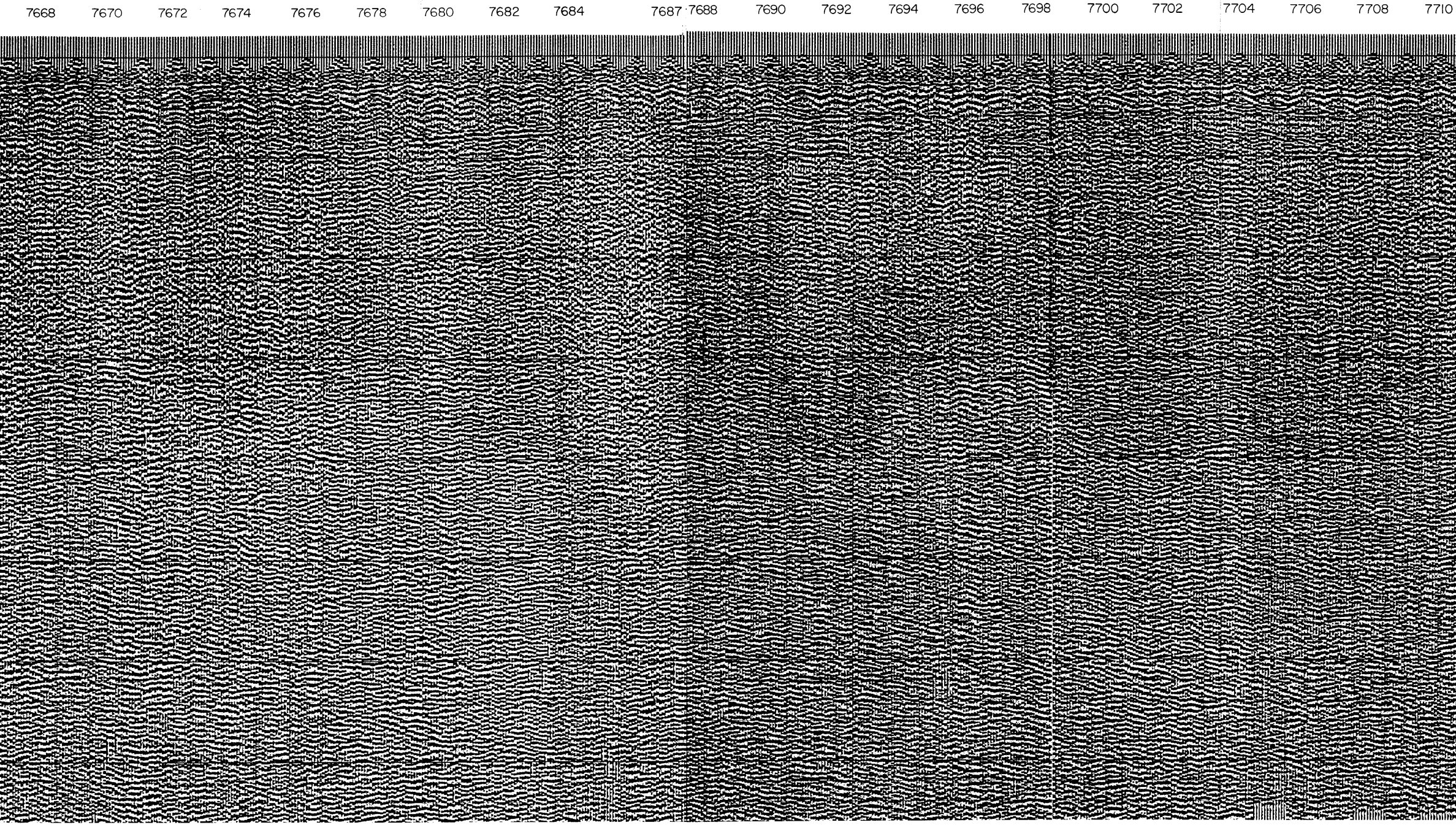
SECTION BY : *Bureau of Mineral Resources*

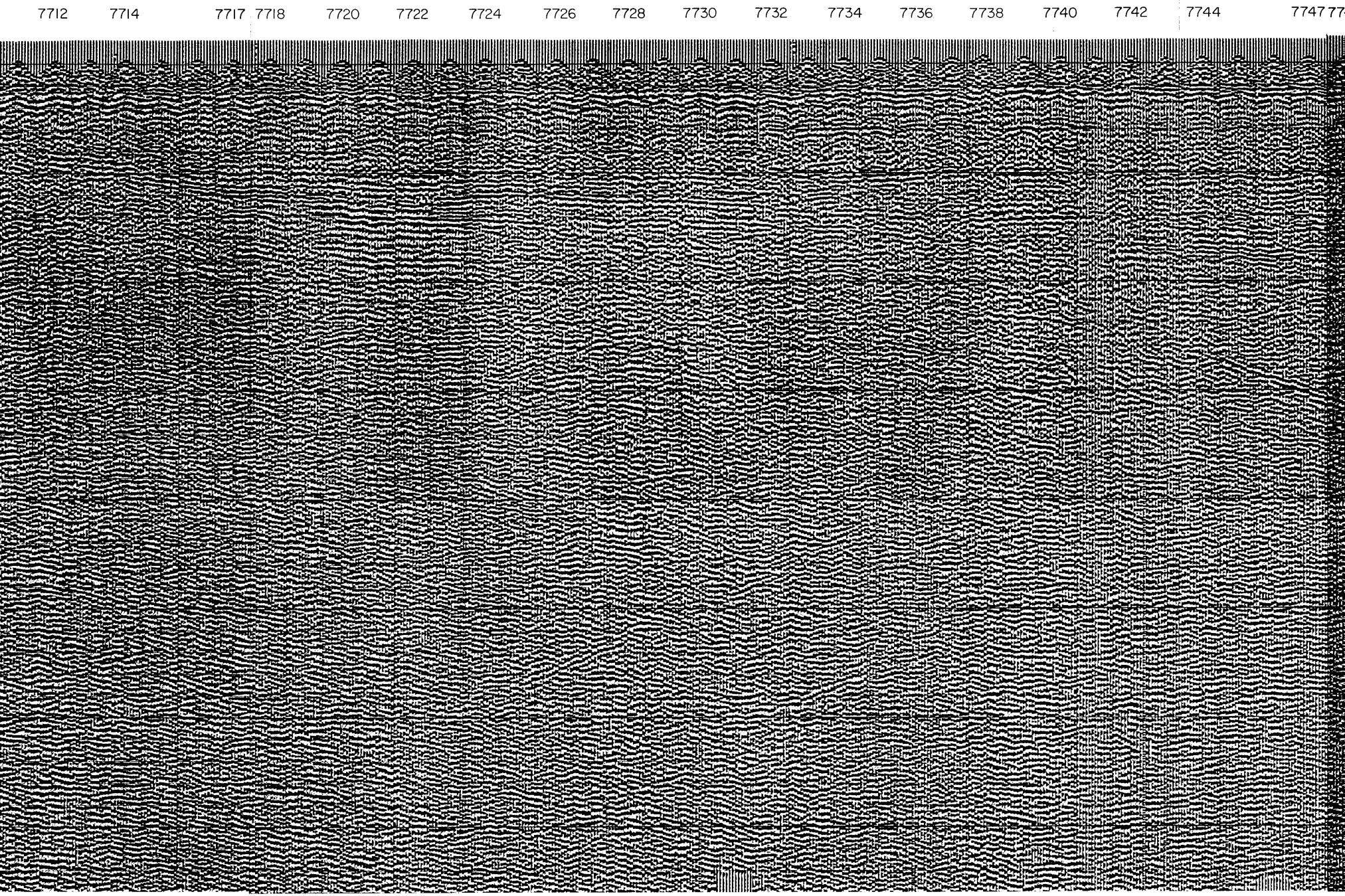
Playback Centre SIE MS 42

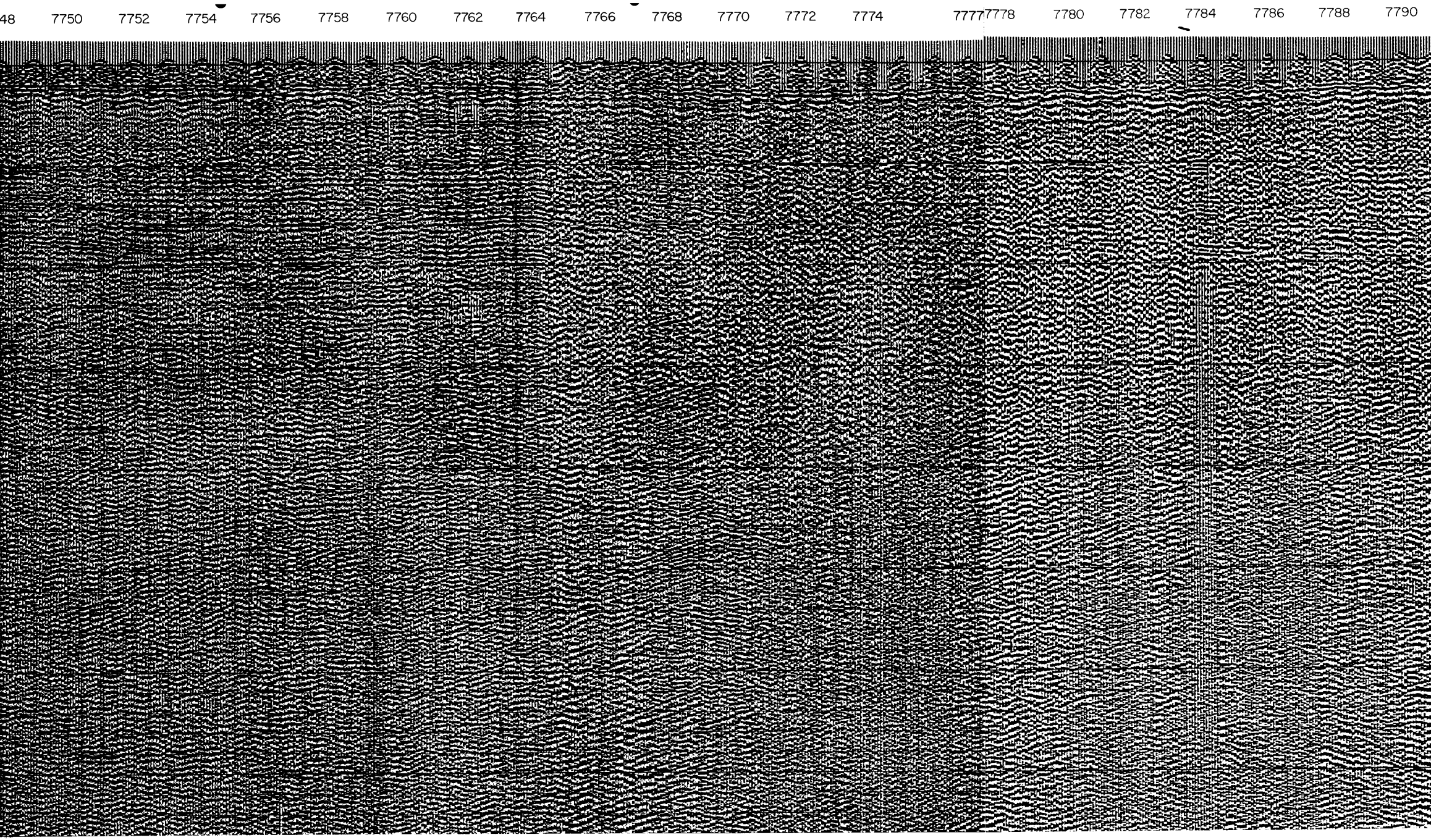
TO ACCOMPANY RECORD No. 1967/90

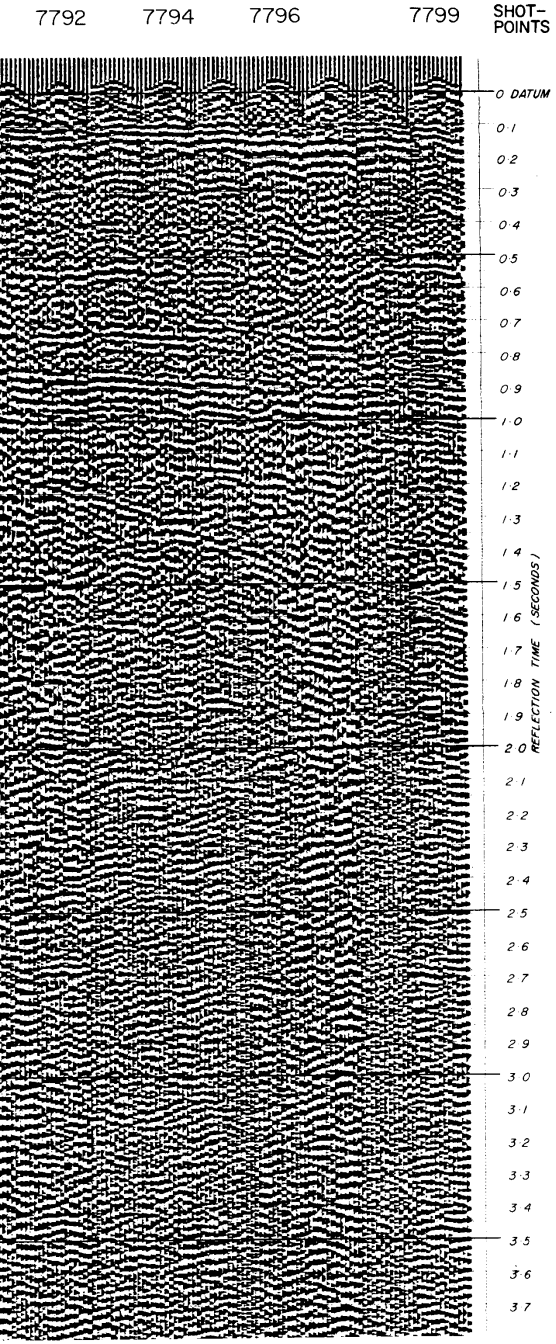
F54/B3-154











CORRECTED RECORD SECTION

(CENTRE 12 TRACES
SINGLE COVERAGE)

RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 7000B

Filters : K24-K160

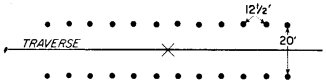
A.G.C. : W.B.

Gain Initial : -60

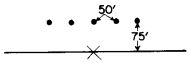
Final : -10

Geophones : HS-J 14 c/s

Geophone pattern :



Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 2/25 1/60

A.G.C. : Super slow

Gain Initial : -50

Final : -30

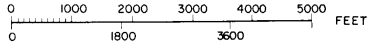
Trip delay : 0·2 s

Compositing : Nil

VELOCITY INFORMATION

t:Δt

HORIZONTAL SCALE



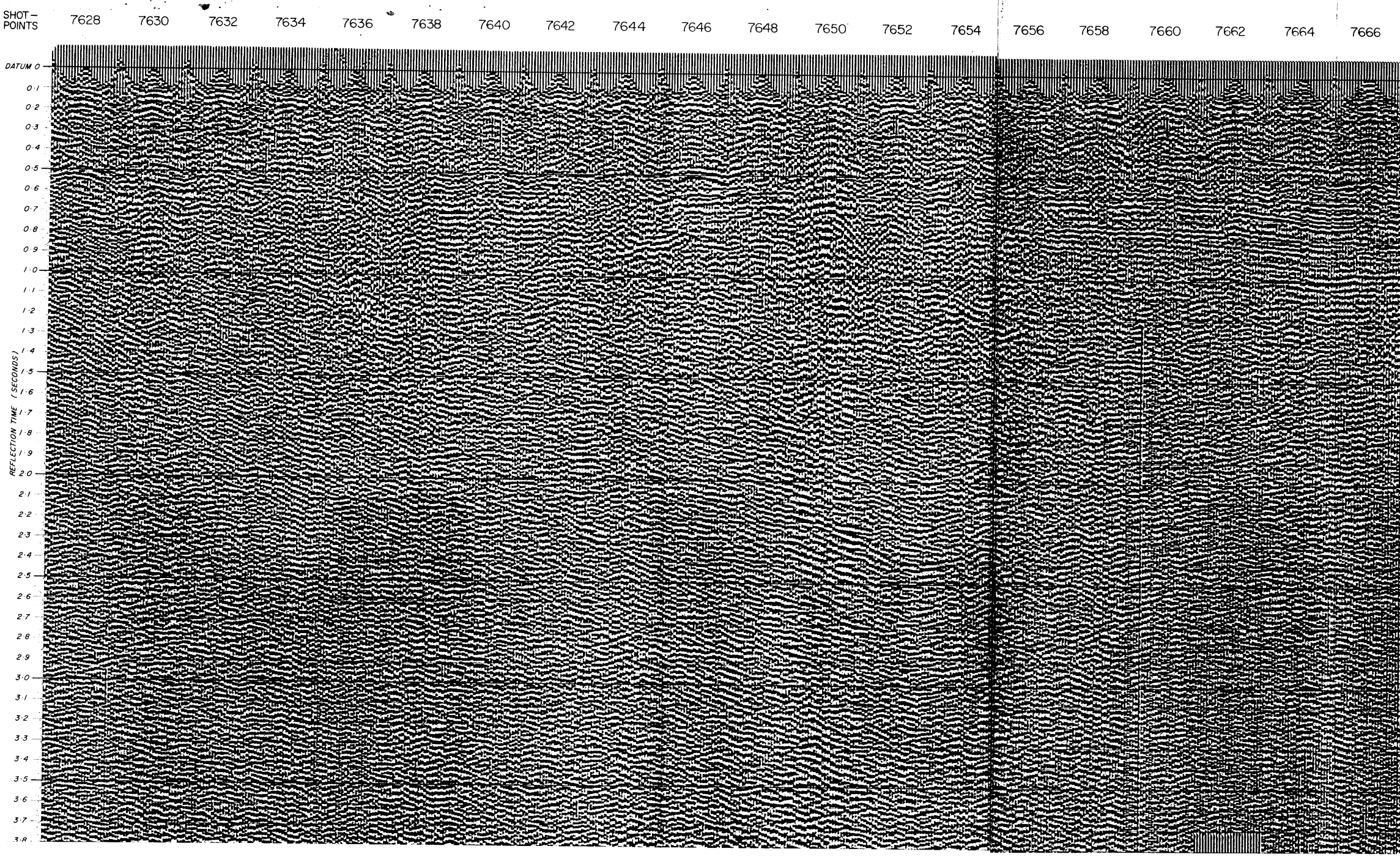
SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1964

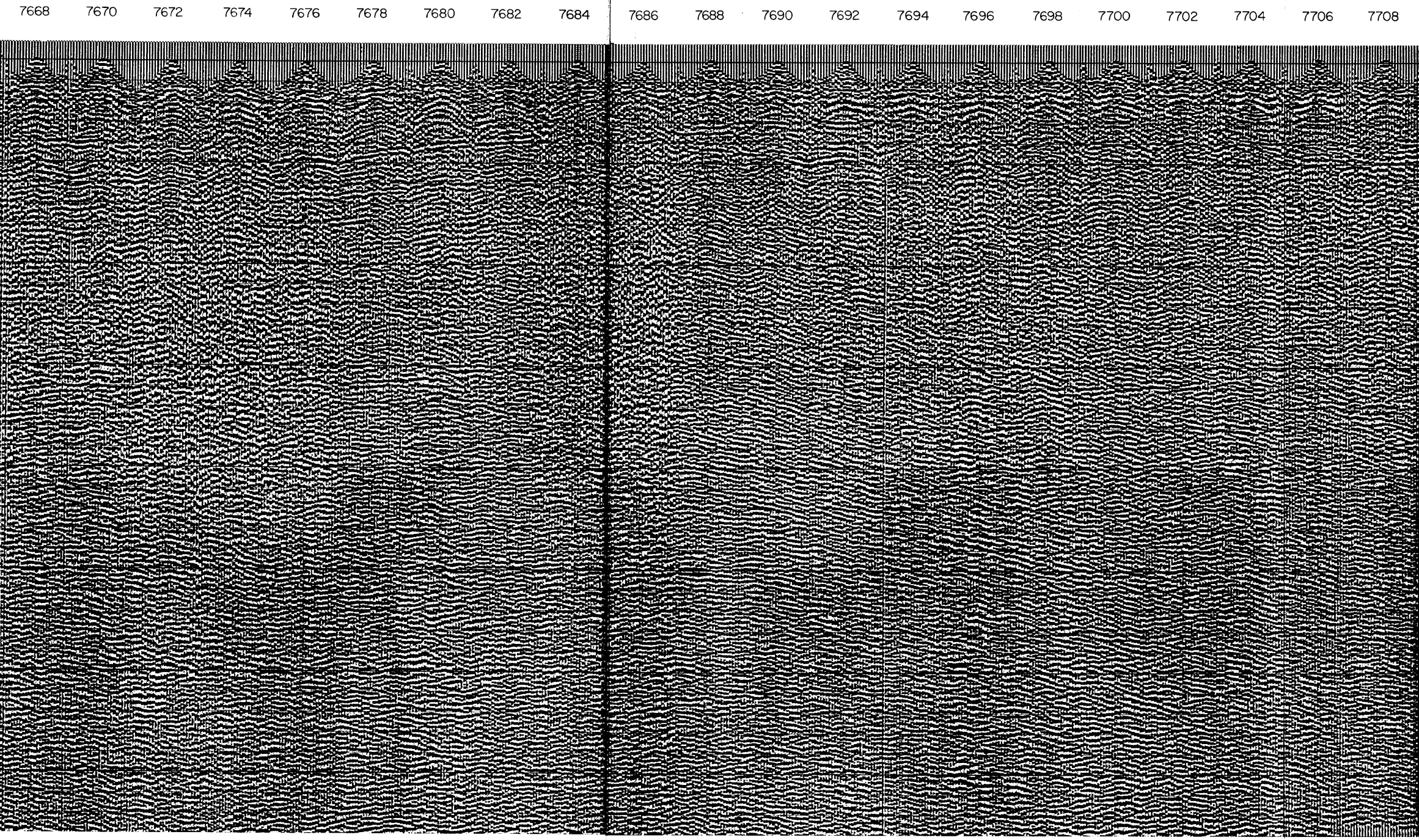
TRAVERSE V

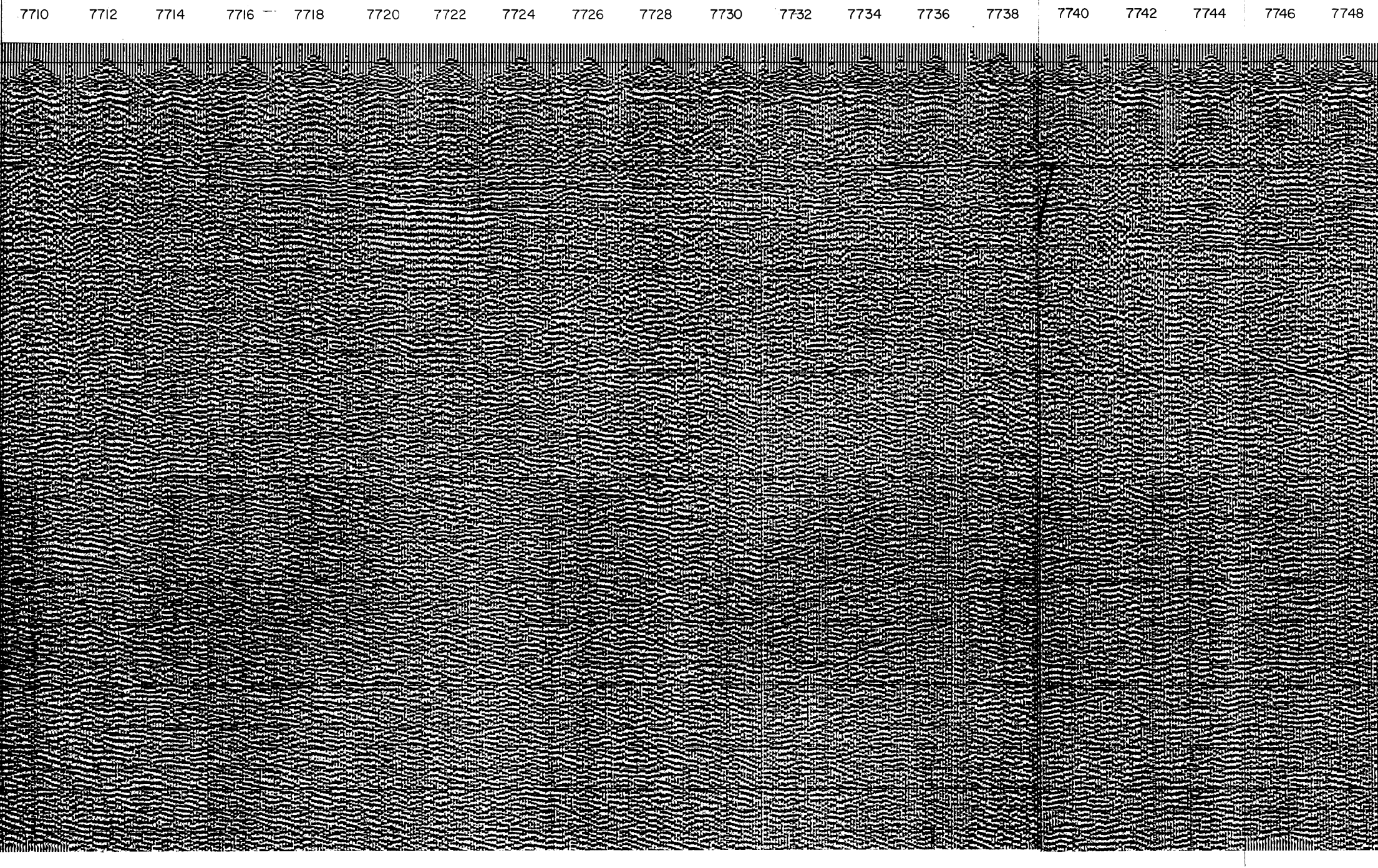
RECORDED BY: *Seismic Party No. 1*

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

TO ACCOMPANY RECORD No. 1967/90 F54/B3-58




7668
7670
7672
7674
7676
7678
7680
7682
7684
7686
7688
7690
7692
7694
7696
7698
7700
7702
7704
7706
7708



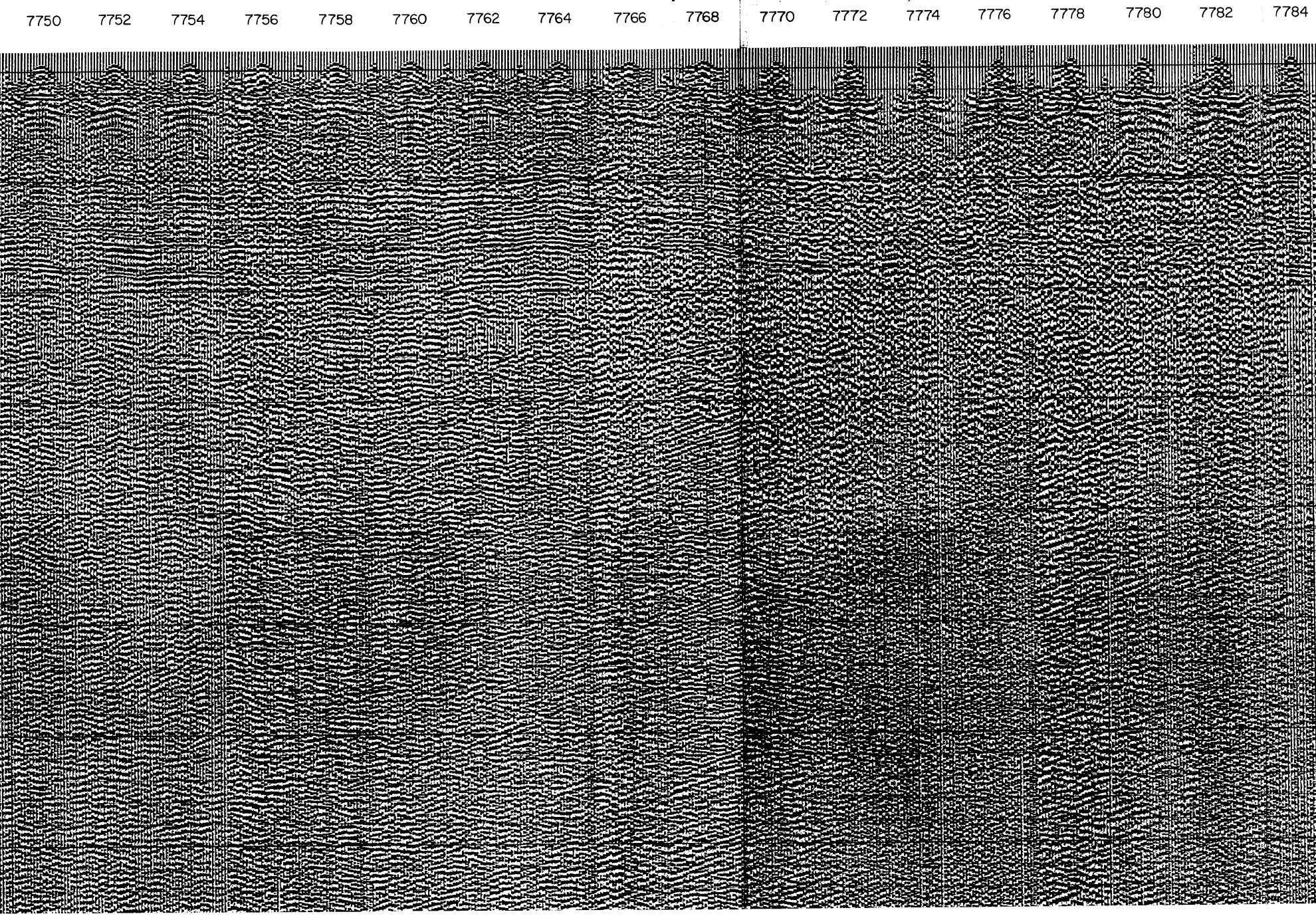
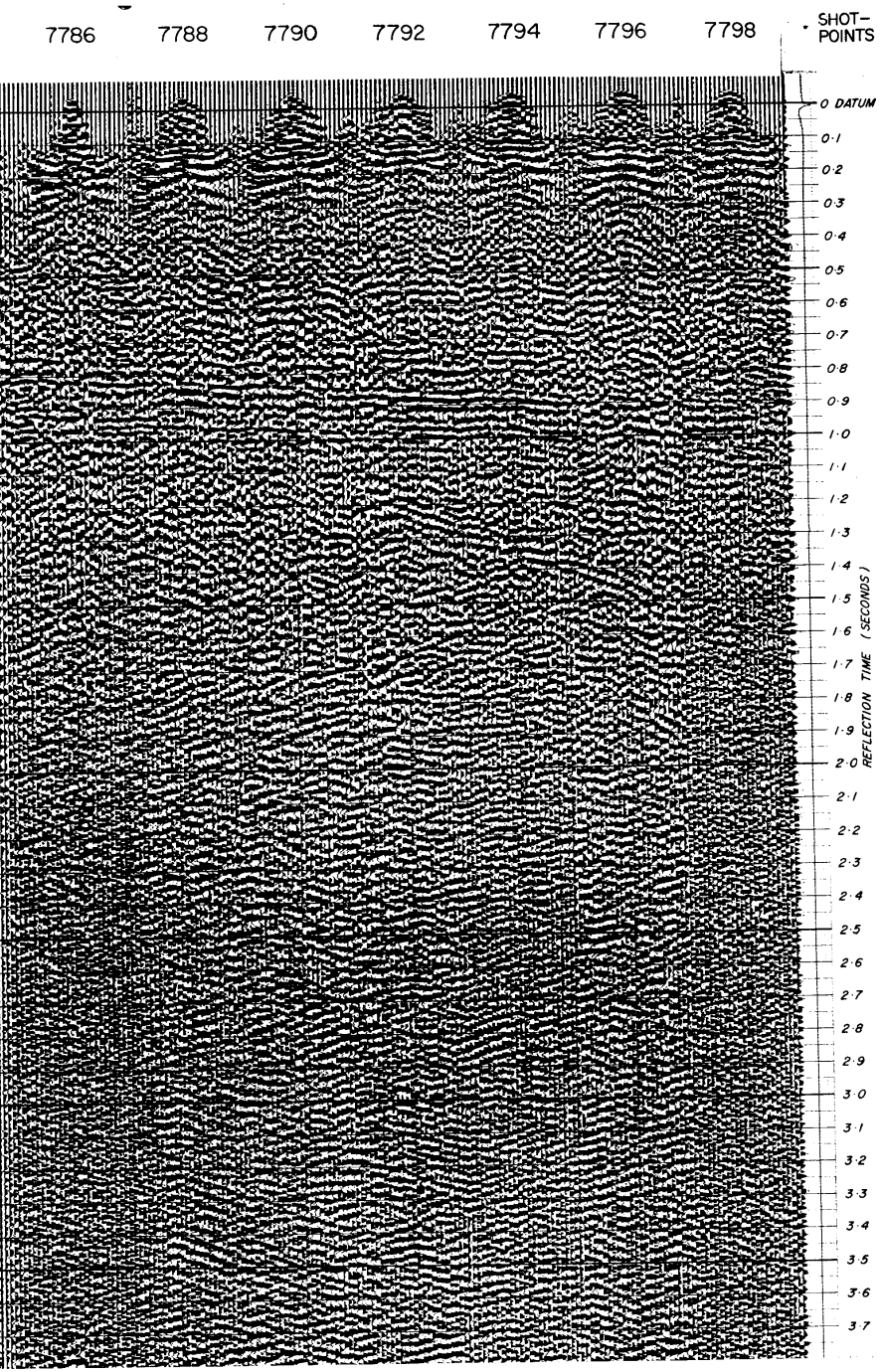


PLATE 16

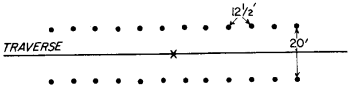


CORRECTED RECORD SECTION

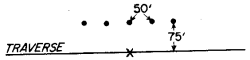
(EVEN SHOT-POINTS
SINGLE COVERAGE)

RECORDING INFORMATION

Magnetic Recorder : DS7-7
Amplifiers : 7000B
Filters : K24 - K160
A.G.C. : W.B.
Gain Initial : -60
Final : -10
Geophones : HS-J 14 c/s
Geophone pattern :


12½′
20′
TRAVERSE

Shot-hole pattern :


50′
75′
TRAVERSE

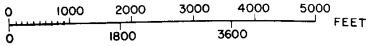
PLAYBACK INFORMATION

Filters : 2/25 1/60
A.G.C. : Super slow
Gain Initial : -50
Final : -30
Trip delay : 0·2 s
Compositing : Nil

VELOCITY INFORMATION

t:Δt

HORIZONTAL SCALE


0
1000
2000
3000
4000
5000
FEET
0
1800
3600

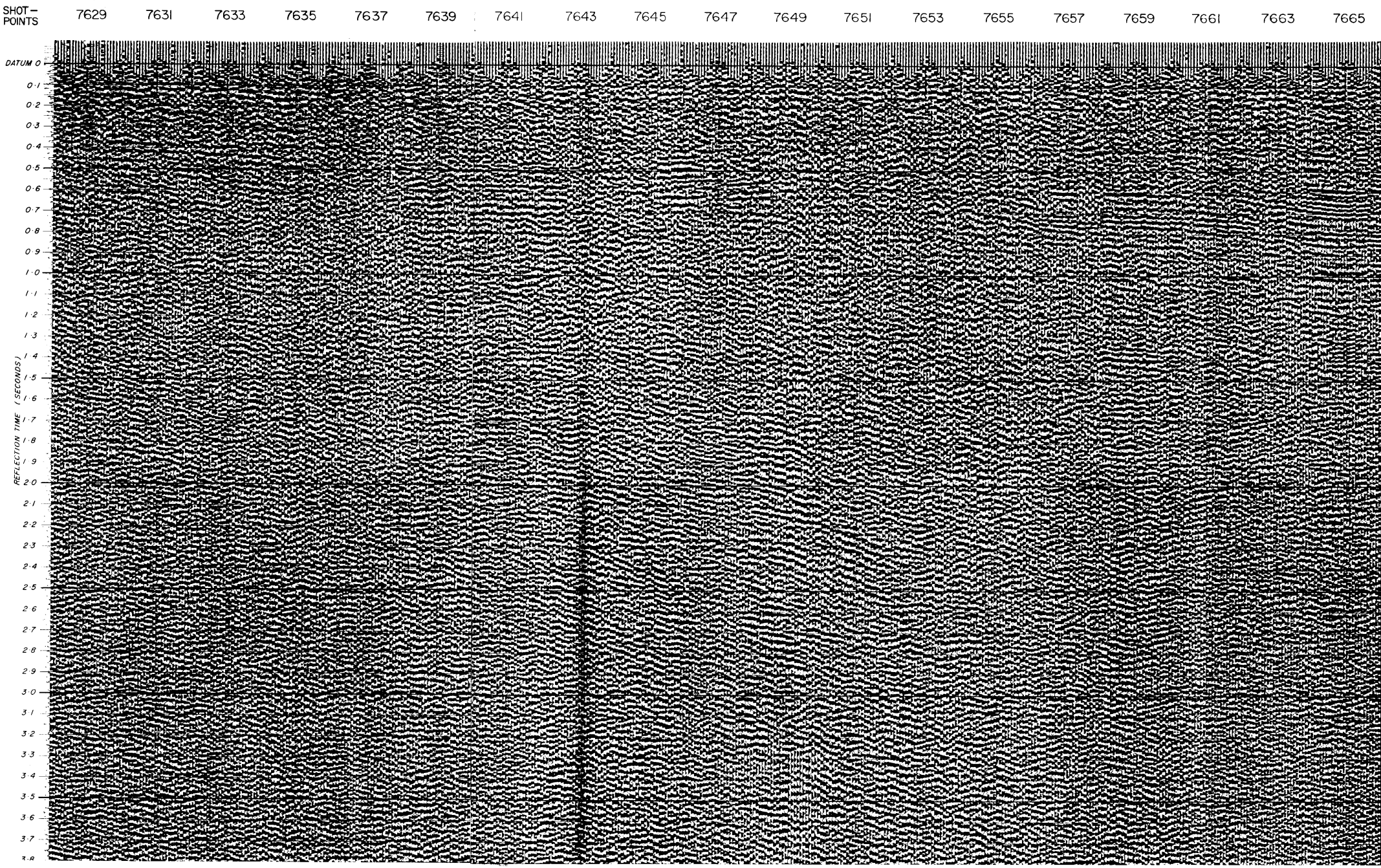
SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1964

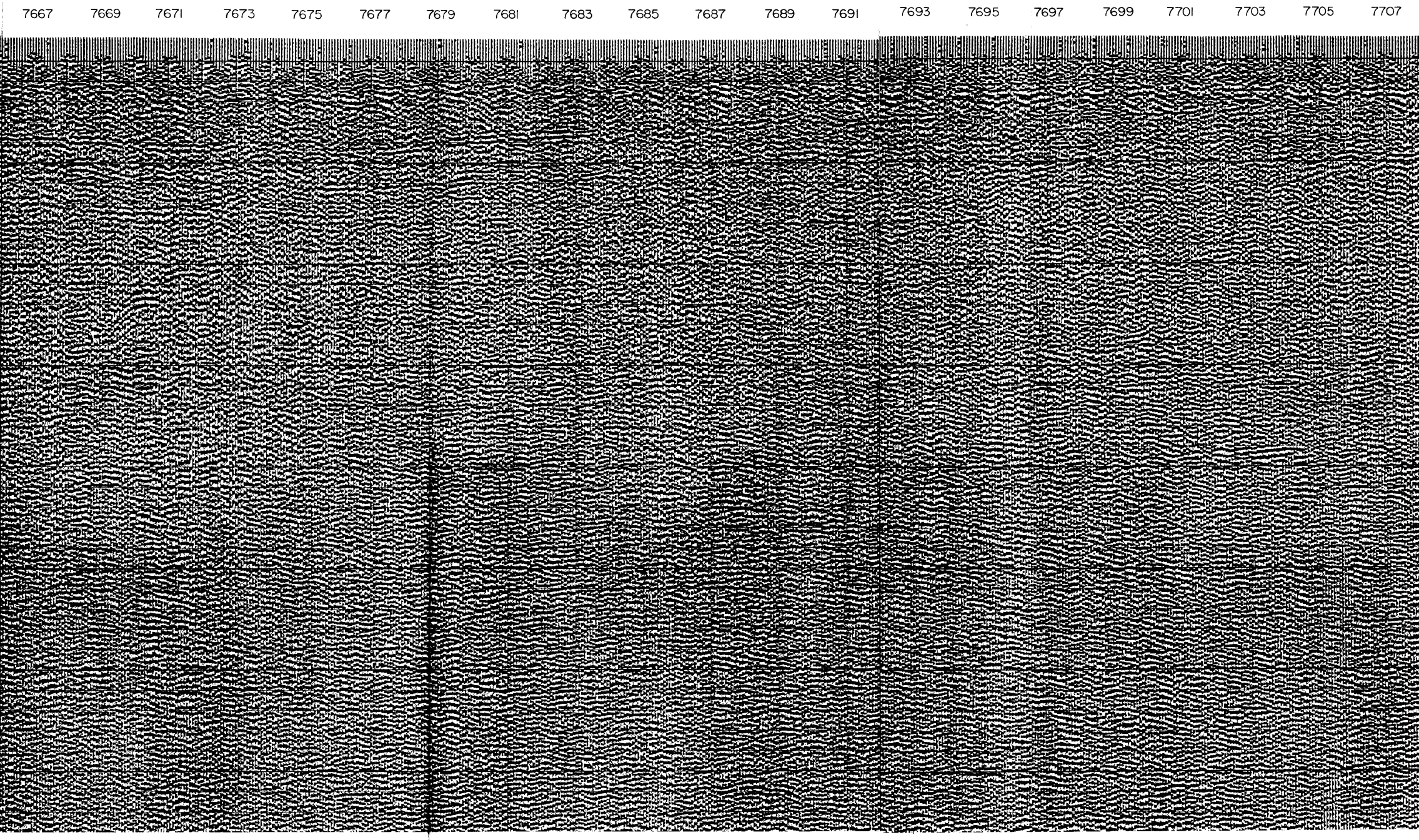
TRAVERSE V

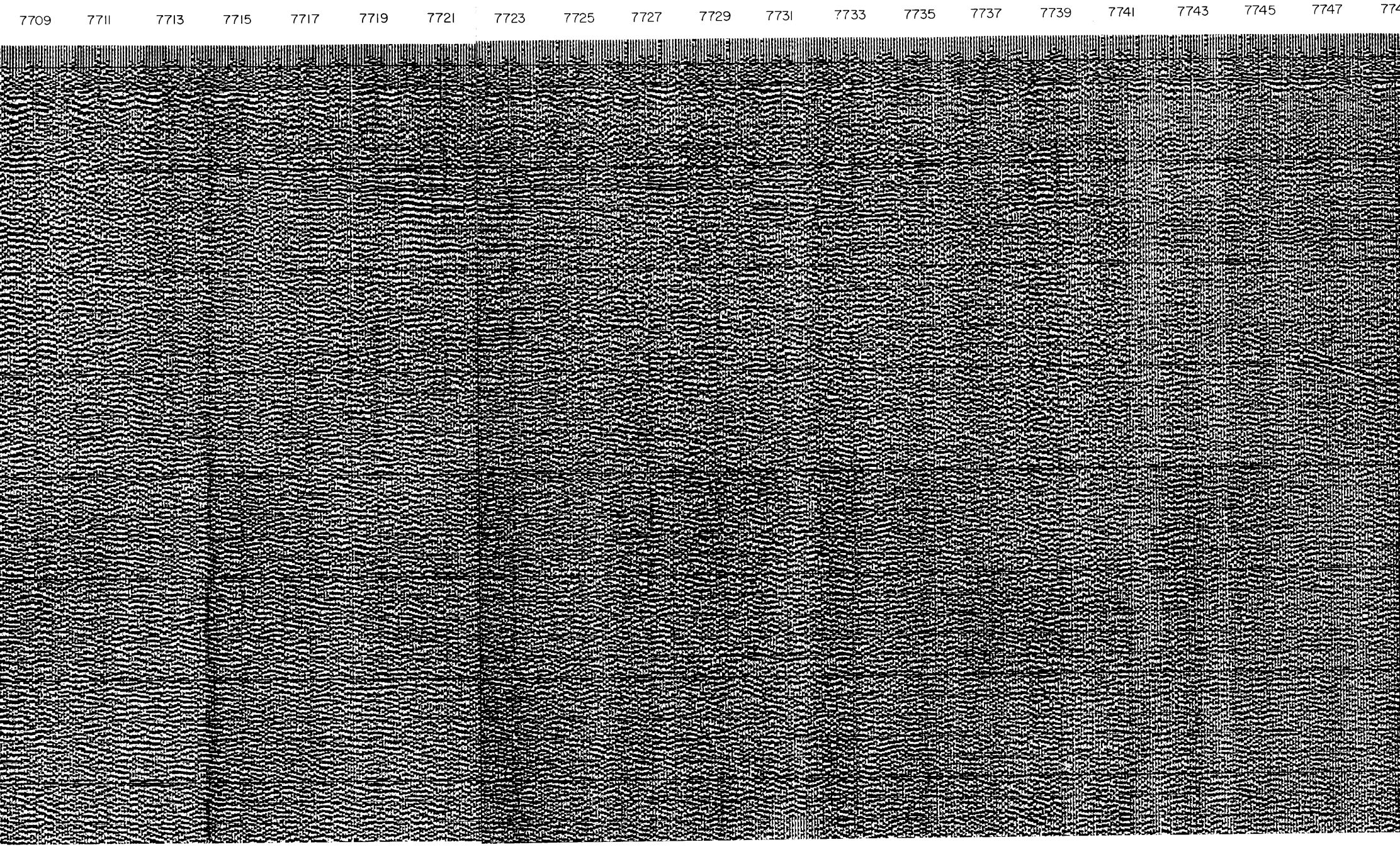
RECORDED BY: *Seismic Party No.1*

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

TO ACCOMPANY RECORD No. 1967/90 F54/B3-57







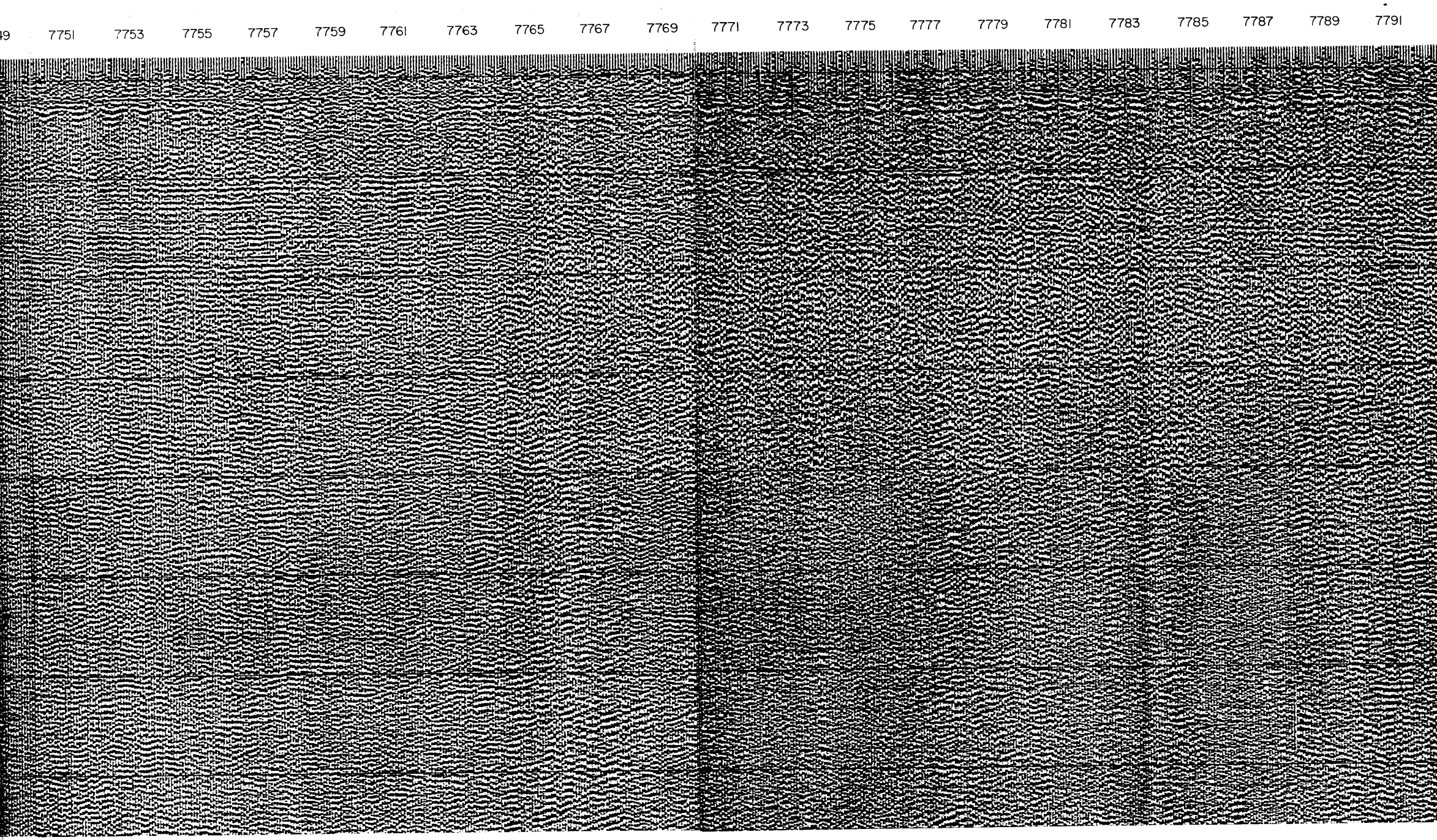
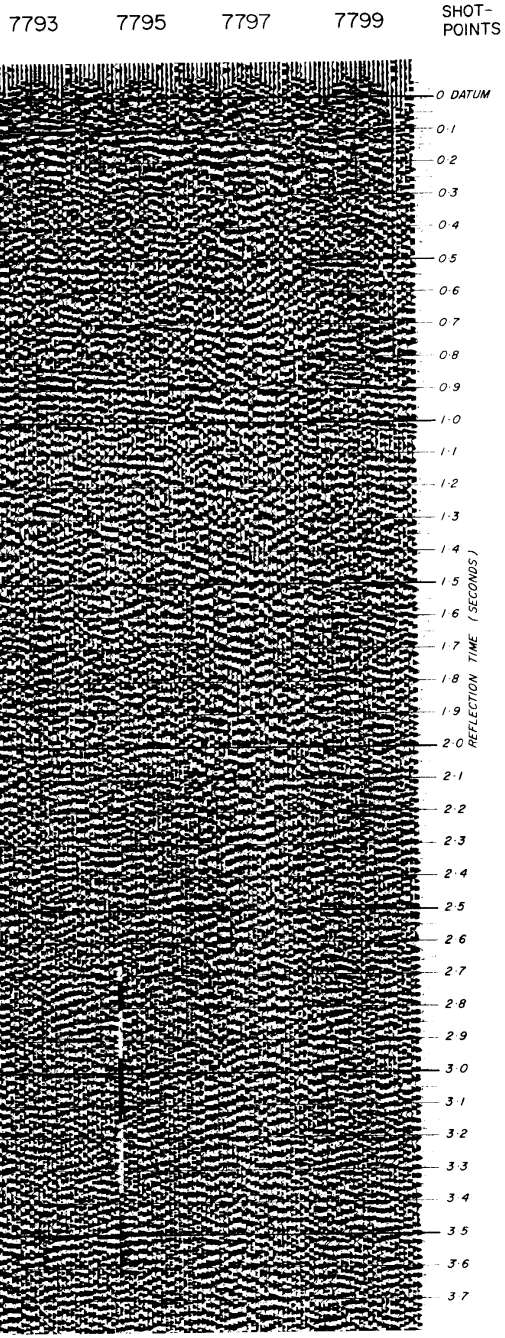


PLATE 17



CORRECTED RECORD SECTION

(2 FOLD HORIZONTAL STACK)

RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 7000B

Filters : K24 - K160

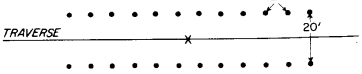
A.G.C. : W.B.

Gain Initial : -60

Final : -10

Geophones : HS - J 14 c/s

Geophone pattern :


12½'
20'
TRAVERSE

Shot-hole pattern :


50'
75'
TRAVERSE

PLAYBACK INFORMATION

Filters : 2/25 1/60

A.G.C. : Super slow

Gain Initial : -50

Final : -30

Trip delay : 0·2s

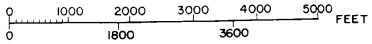
Compositing :

Two fold stack
Double subsurface coverage

VELOCITY INFORMATION

t:Δt

HORIZONTAL SCALE


0
1000
2000
3000
4000
5000
FEET
0
1800
3600

SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1964

TRAVERSE V

RECORDED BY: *Seismic Party No. I*

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

TO ACCOMPANY RECORD No. 1967/90 F54/B3-59

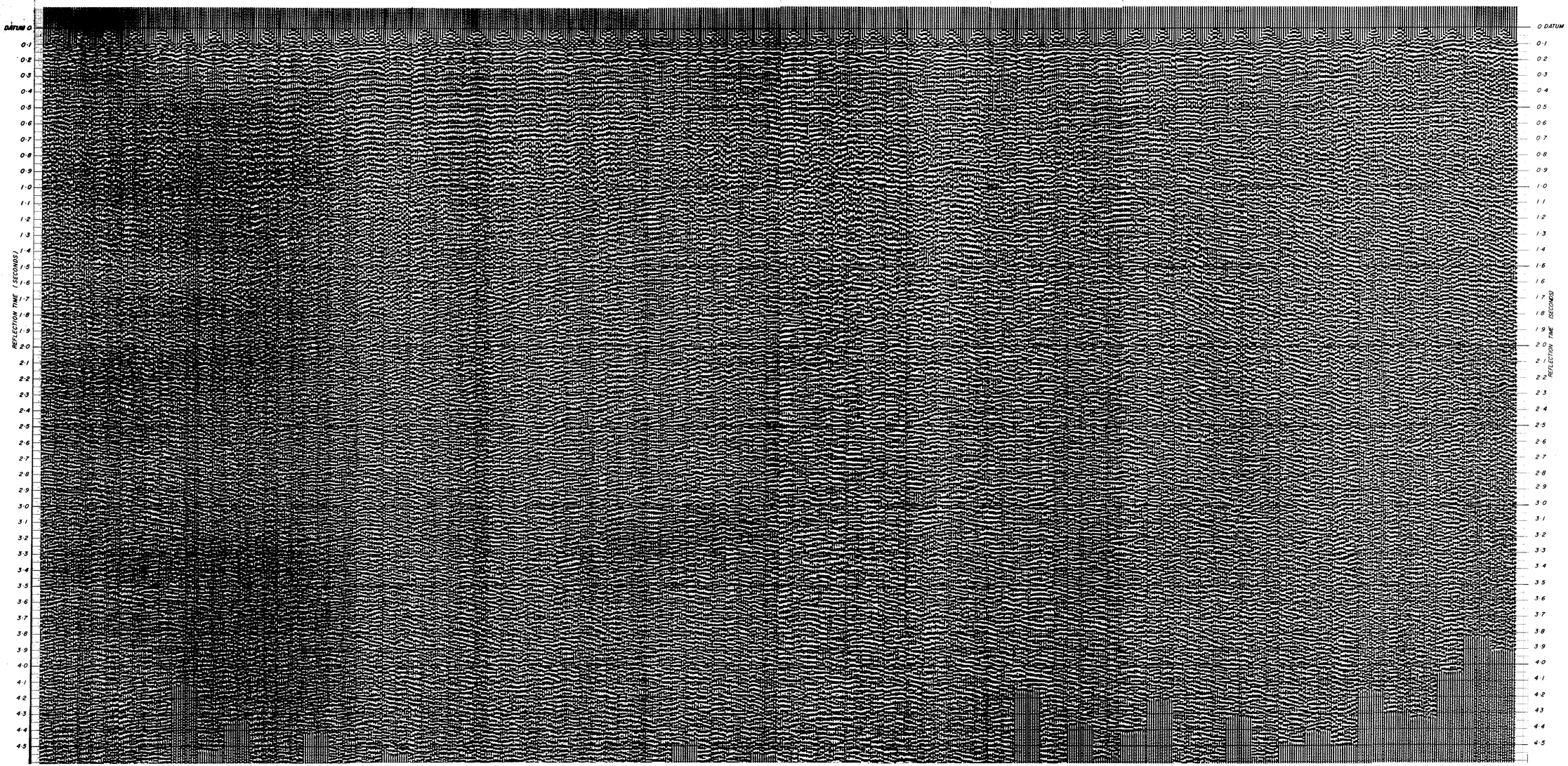


PLATE 18

CORRECTED RECORD SECTION

(CENTRE 12 TRACES)
(SINGLE COVERAGE)

RECORDING INFORMATION

Magnetic Recorder DS7-7

Amplifiers : 7000 B

Filters : K24 – K120

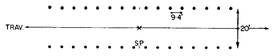
A.G.C. : WB

Gain Initial : –60

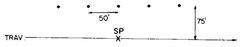
Final : –10

Geophones : HS-J 14 c/s

Geophone pattern : 32 geophones



Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 2/25 1/60

A.G.C. : Super Slow

Gain Initial : –40

Final : –20

Trip delay : 0·2 s

Compositing : Nil

VELOCITY INFORMATION

t; Δt

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1800 3600

SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE B

RECORDED BY: *Seismic Party No. 1*

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

F54/B3-90

TO ACCOMPANY RECORD No. 1967/90

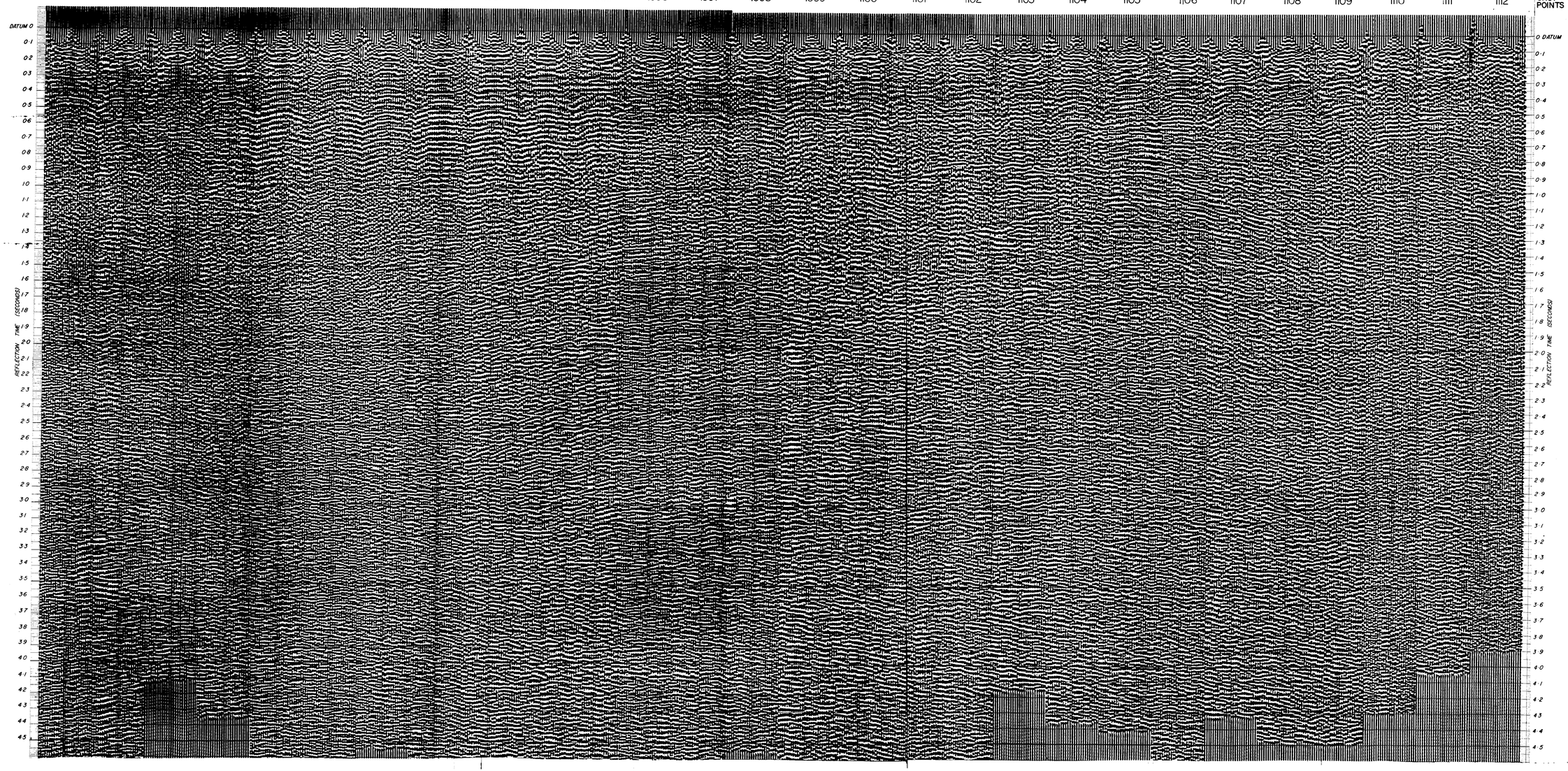


PLATE 19

CORRECTED RECORD SECTION
(WHOLE NUMBER SHOT POINTS)
(SINGLE COVERAGE)

RECORDING INFORMATION

Magnetic Recorder DS7-7

Amplifiers : 7000 B

Filters : K24—K 120

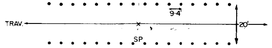
A.G.C. : WB

Gain Initial :—60

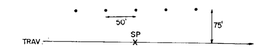
Final :—10

Geophones : HS-J 14 c/s

Geophone pattern : 32 geophones



Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 2/25 1/60

A.G.C. : Super Slow

Gain Initial :—40

Final :—20

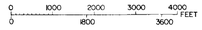
Trip delay : 0·2 s

Compositing : Nil

VELOCITY INFORMATION

1:Δt

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE B

RECORDED BY : *Seismic Party No.1*

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

F54/83-89

TO ACCOMPANY RECORD No. 1967/90

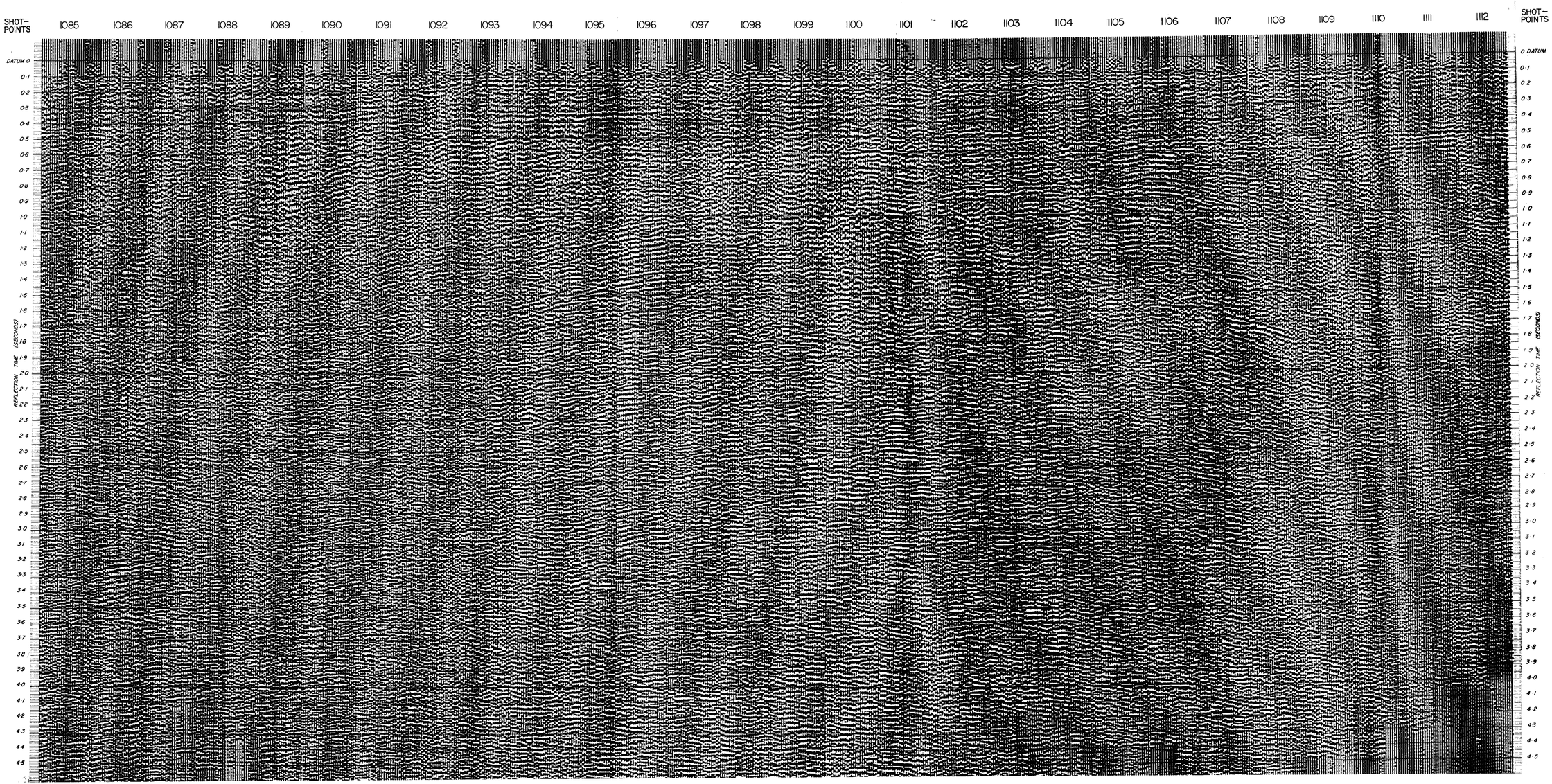


PLATE 20

CORRECTED RECORD SECTION

(2 FOLD HORIZONTAL STACK)

RECORDING INFORMATION

Magnetic Recorder DS7-7

Amplifiers : 7000 B

Filters : K24-K120

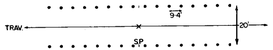
A.G.C. : WB

Gain Initial :-60

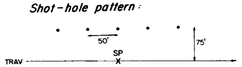
Final :-10

Geophones : HS-J 14 c/s

Geophone pattern : 32 geophones



Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 2/25 1/60

A.G.C. : Super Slow

Gain Initial :-40

Final :-10

Trip delay :0·2 s

Compositing :

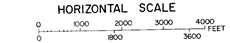
2 FOLD STACK

DOUBLE SUBSURFACE COVERAGE

VELOCITY INFORMATION

$t : \Delta t$

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1964

TRAVERSE B

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* F54/83-91

TO ACCOMPANY RECORD No.1967/90

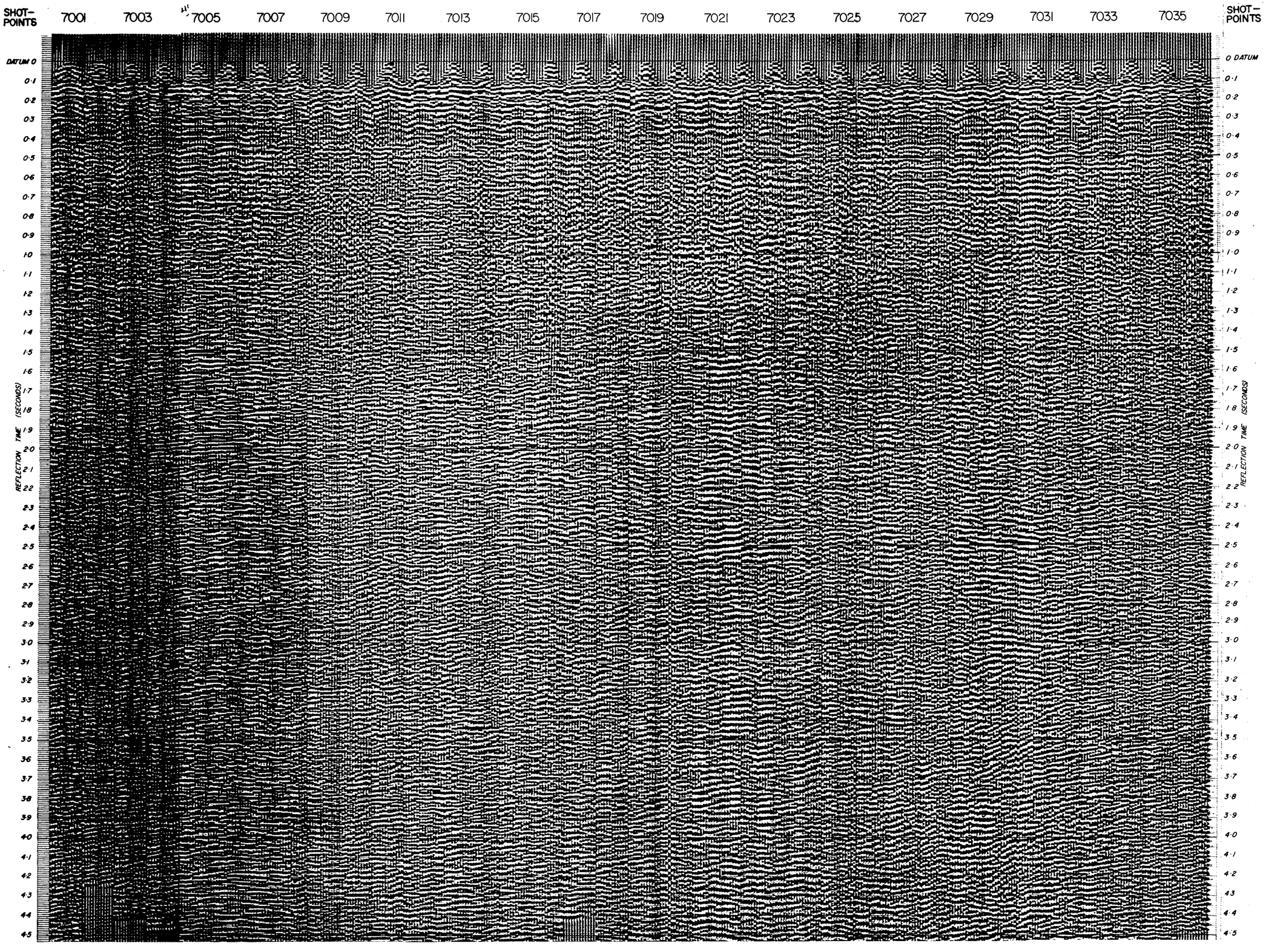


PLATE 21

CORRECTED RECORD SECTION

(CENTRE 12 TRACES)
(SINGLE COVERAGE)

RECORDING INFORMATION

Magnetic Recorder DS7-7

Amplifiers : 7000 B

Filters : K24 – K120

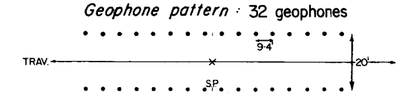
A.G.C. : WB

Gain Initial : –60

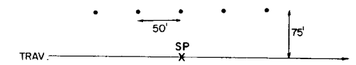
Final : –10

Geophones : HS-J 14 c/s

Geophone pattern : 32 geophones



Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 2/25 1/60

A.G.C. : Super Slow

Gain Initial : –40

Final : –20

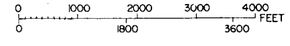
Trip delay : 0·2 s

Compositing : Nil

VELOCITY INFORMATION

t : Δt

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1964

TRAVERSE S

RECORDED BY: *Seismic Party No.1*

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

F54/B3-87

TO ACCOMPANY RECORD No. 1967/90

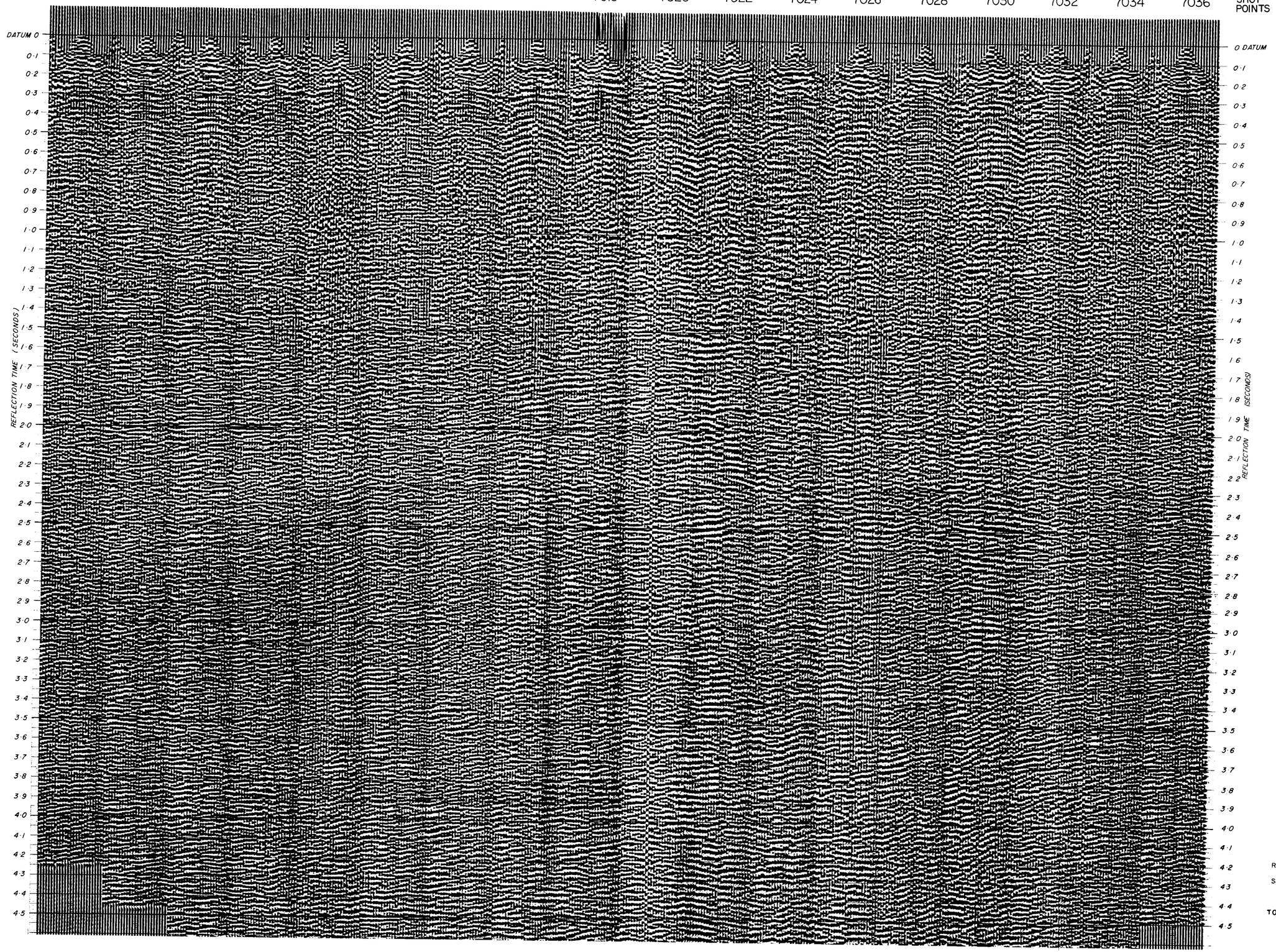


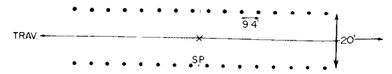
PLATE 22

CORRECTED RECORD SECTION

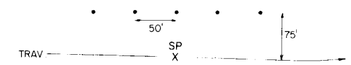
(EVEN SHOT POINTS)
(SINGLE COVERAGE)

RECORDING INFORMATION

Magnetic Recorder DS7-7
Amplifiers : 7000 B
Filters : K24-K120
A.G.C. : WB
Gain Initial : -60
Final : -10
Geophones : HS-J 14 c/s
Geophone pattern : 32 geophones



Shot-hole pattern :



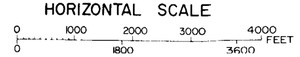
PLAYBACK INFORMATION

Filters : 2/25 1/60
A.G.C. : Super Slow
Gain Initial : -40
Final : -20
Trip delay : 0·2 s
Compositing : Nil

VELOCITY INFORMATION

t:Δt

HORIZONTAL SCALE



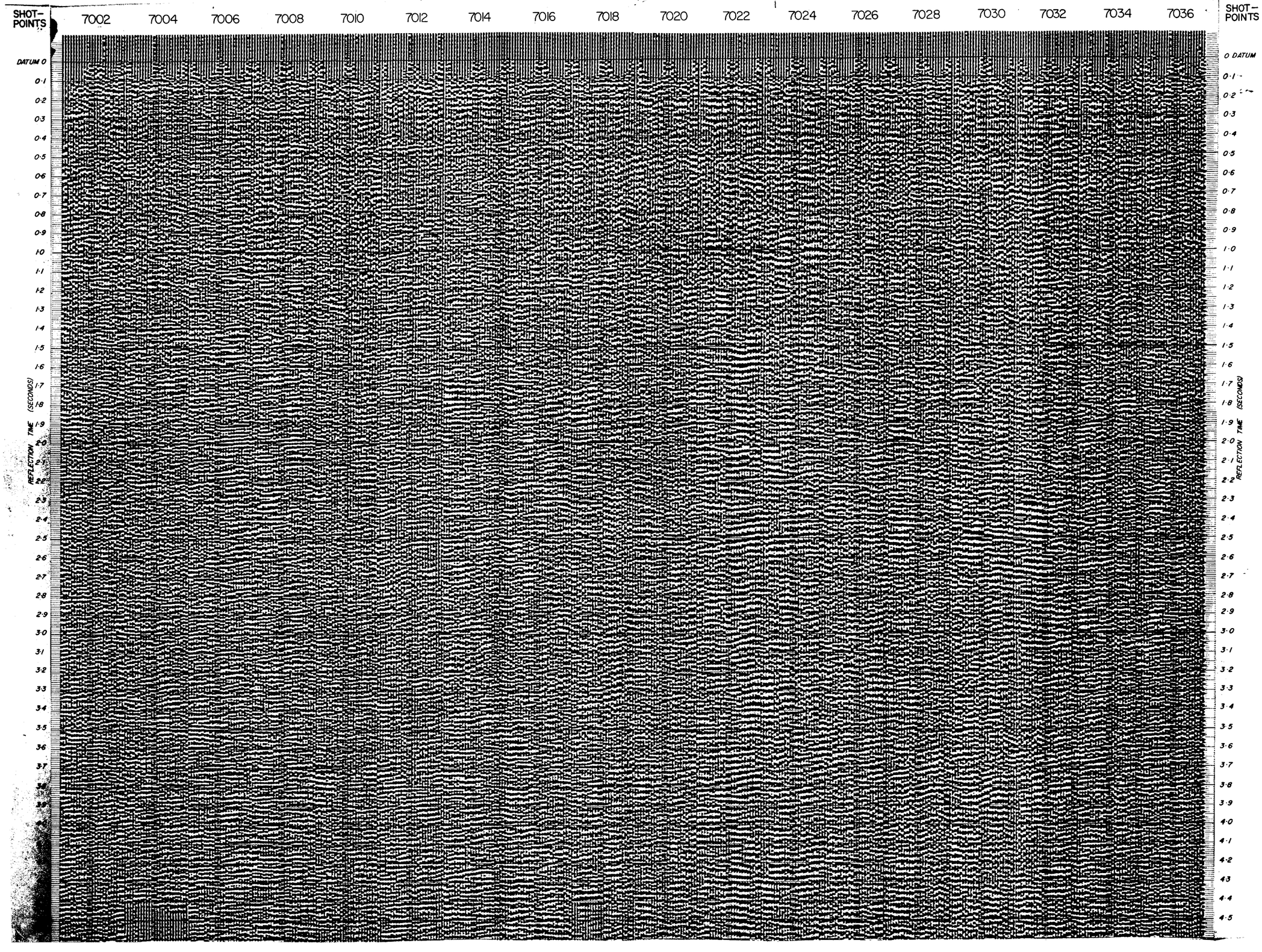
SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE S

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F54/83-86

TO ACCOMPANY RECORD No. 1967/90



CORRECTED RECORD SECTION

(2 FOLD HORIZONTAL STACK)

RECORDING INFORMATION

Magnetic Recorder DS7-7

Amplifiers : 7000 B

Filters : K24 – K120

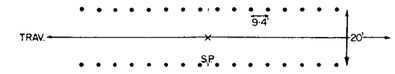
A.G.C. : WB

Gain Initial : –60

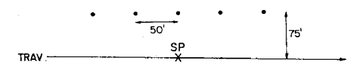
Final : –10

Geophones : HS-J 14 c/s

Geophone pattern : 32 geophones



Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 2/25 1/60

A.G.C. : Super Slow

Gain Initial : –40

Final : –10

Trip delay ·0·2 s

Compositing :

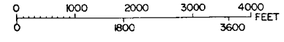
Two fold stack

Double subsurface coverage

VELOCITY INFORMATION

t : Δt

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1964

TRAVERSE S

RECORDED BY: *Seismic Party No.1*

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

F54/83-88

TO ACCOMPANY RECORD No. 1967/90

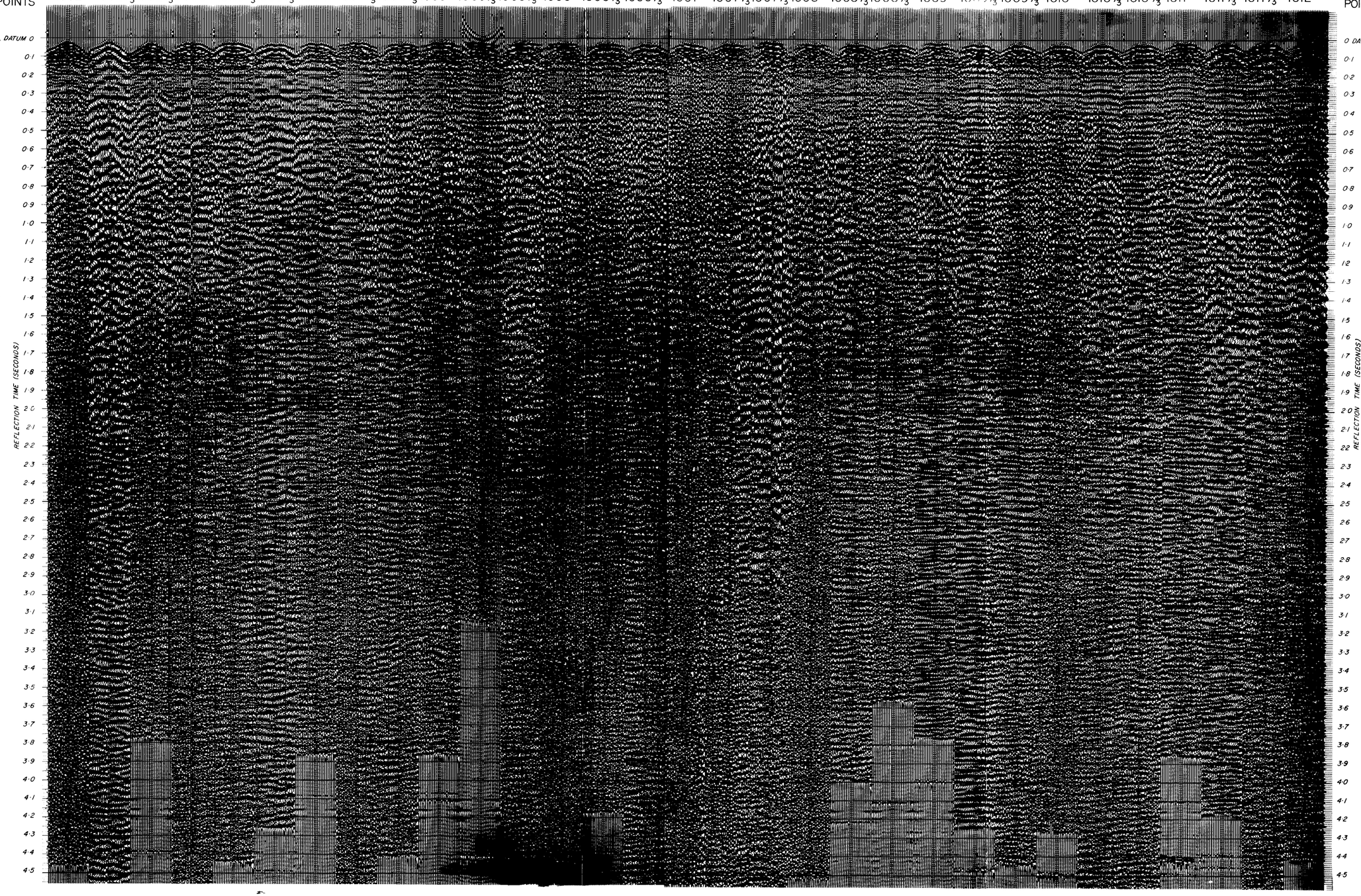


PLATE 24

CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7 – 7

Amplifiers : 7000B

Filters : K18 – K160

A.G.C. : W.B.

Gain Initial : –60

Final : –10

Geophones : HSJ – 14 c/s

Geophone pattern :

16/trace, 20' apart in line
Station Interval 50'

Shot-hole pattern :

Single
Depth 90'
Charge 2½lb

PLAYBACK INFORMATION

Filters : 1/20 – 1/78

A.G.C. : S.

Gain Initial : –50

Final : –20

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

Sonic log Canary No1 Bore
and t:Δt analysis

HORIZONTAL SCALE

FEET

0 500 1000 1500 2000 2500
0 600 1200 1800

SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1963

TRAVERSE A

TO ACCOMPANY RECORD No. 1967/90

RECORDED BY : *Seismic Party No.1*

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

F54/B3-153

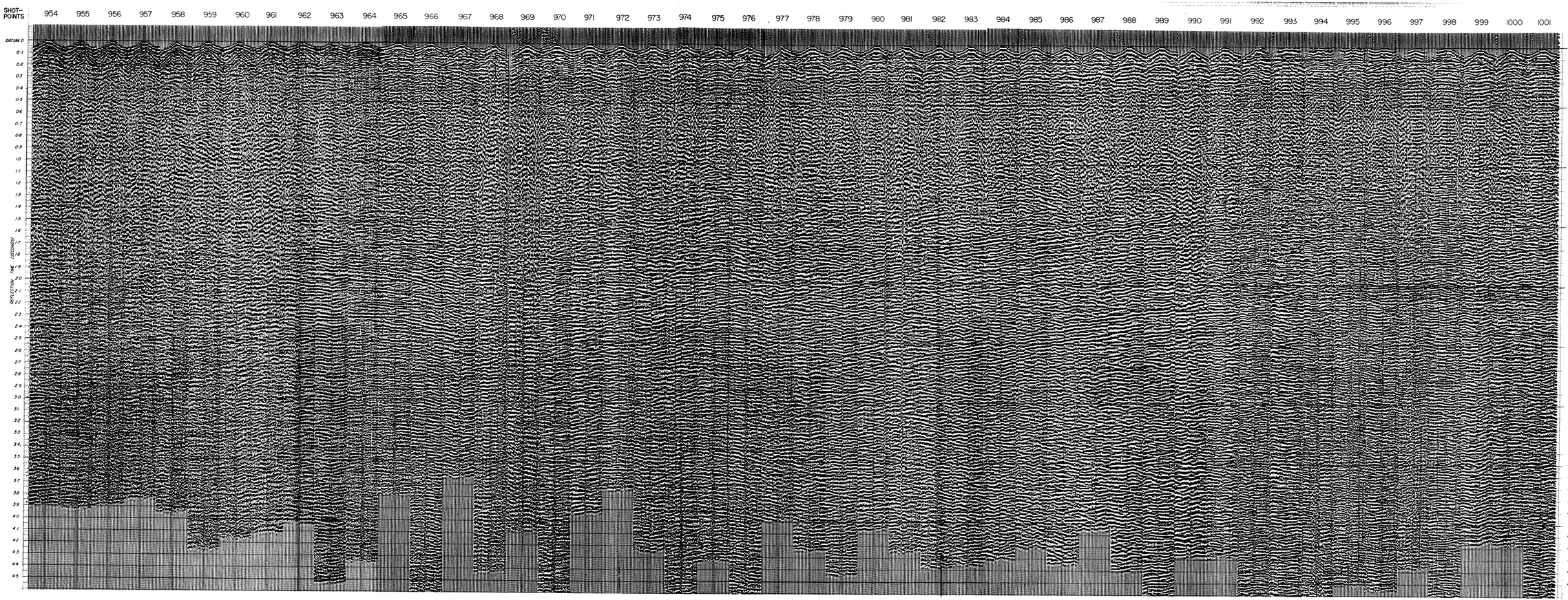


PLATE 25

CORRECTED RECORD SECTION
(SINGLE COVERAGE)

RECORDING INFORMATION

Magnetic Recorder : DS7-7
Amplifiers : 7000B
Filters : K18-K160
A.G.C. : WB
Gain Initial : −57
Final : −20
Geophones : HSJ 14c/s
Geophone pattern : 24 geophones

PLAYBACK INFORMATION

Filters : 2/25 V60
A.G.C. : Super Slow
Gain Initial : −50
Final : −20
Trip delay : 0·2 s
Compositing : Nil

VELOCITY INFORMATION

1.61

HORIZONTAL SCALE

0 1000 2000 3000 FEET
0 900 1800 2700

SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1964

TRAVERSE A

RECORDED BY *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* F54/83-92

TO ACCOMPANY RECORD No. 1967/90

PLATE 26

CORRECTED RECORD SECTION

(CENTRE 6 TRACES)
(SINGLE COVERAGE)

SHOT-POINTS

855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953

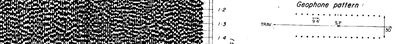
REFLECTION TIME (SECONDS)

0 DATUM 0·1 0·2 0·3 0·4 0·5 0·6 0·7 0·8 0·9 1·0 1·1 1·2 1·3 1·4 1·5 1·6 1·7 1·8 1·9 2·0 2·1 2·2 2·3 2·4 2·5 2·6 2·7 2·8 2·9 3·0 3·1 3·2 3·3 3·4 3·5 3·6 3·7 3·8 3·9 4·0 4·1 4·2 4·3 4·4 4·5

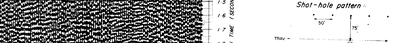
REFLECTION TIME (SECONDS)

RECORDING INFORMATION

Magnetic Recorder : DS7-7
Amplifiers : 7000B
Filters : K24 - K120
A.G.C. : W8
Gain Initial : -60
Final : -20
Geophones : HSJ 14c/s
Geophone pattern :



Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 2/25 1/60
A.G.C. : Super Slow
Gain Initial : -40
Final : -20
Trip delay : 0·2s
Composting : Nil

VELOCITY INFORMATION

f.d.t

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 800 1600

SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE A

RECORDED BY : *Seismic Party No.1*
SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F54/83-94

TO ACCOMPANY RECORD No. 1967/90

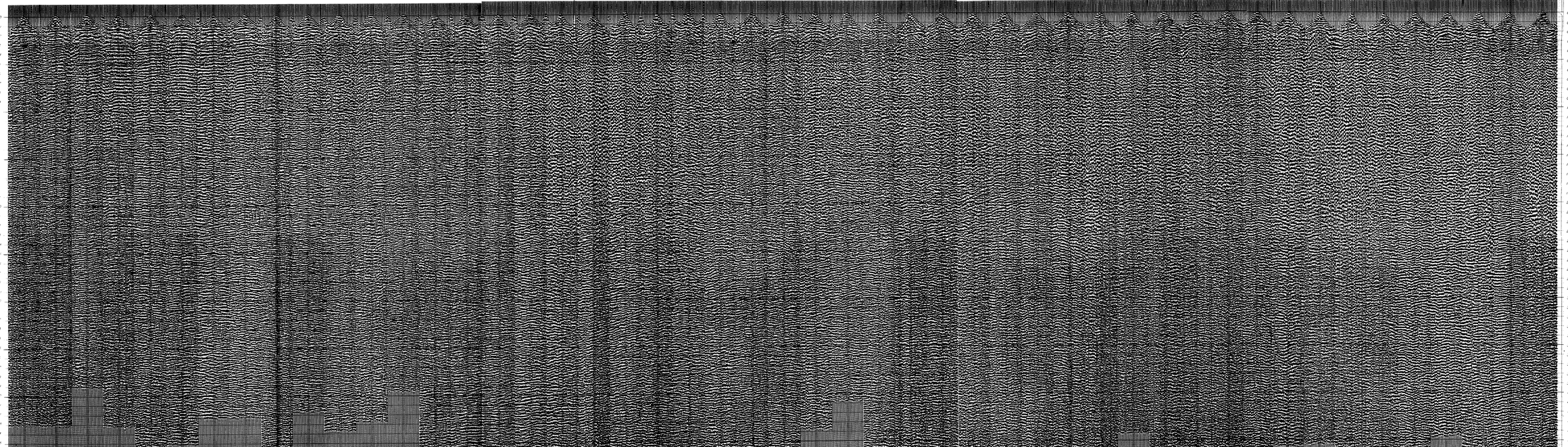


PLATE 27

CORRECTED RECORD SECTION

(EVEN SHOT POINTS)
(SINGLE COVERAGE)

RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 7000B

Filters : K24 - K120

A.G.C. : WB

Gain Initial : -60

Final : -20

Geophones : HSJ 14cA

Geophone pattern :

Shot-hole pattern

PLAYBACK INFORMATION

Filters : 2/25 1/60

A.G.C. : Super Slow

Gain Initial : -40

Final : -20

Trip delay : 0.29

Composhing : Nil

VELOCITY INFORMATION

t-a1

HORIZONTAL SCALE

SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE A

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources*
Playback Centre S/E WG 42 F54/83-93

TO ACCOMPANY RECORD No.1967/90

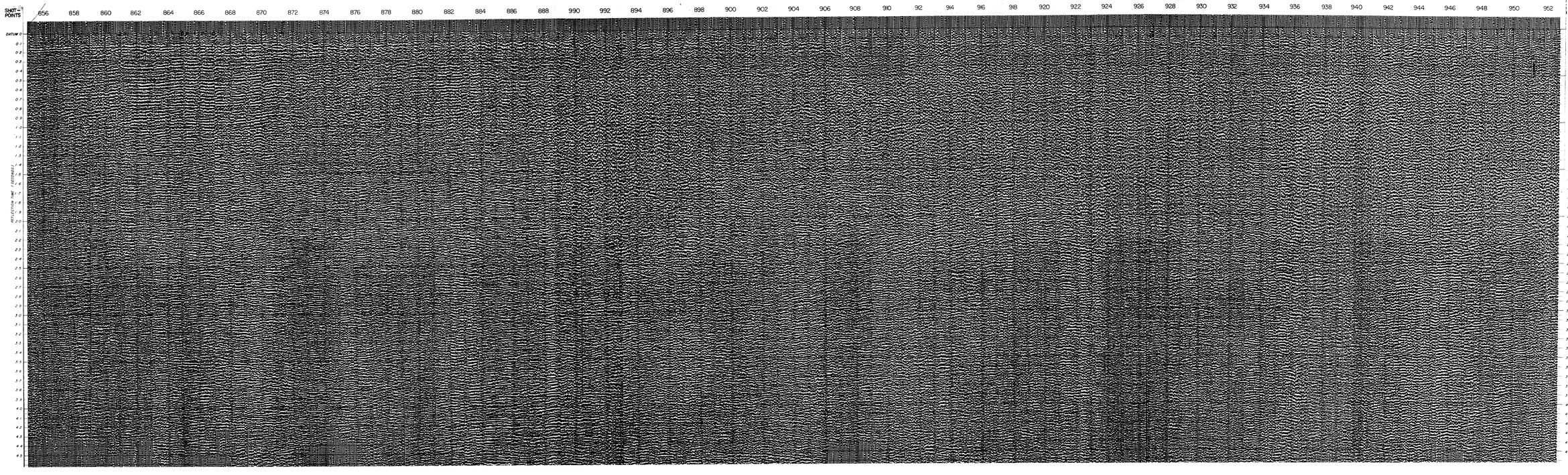


PLATE 28

CORRECTED RECORD SECTION
(2 FOLD HORIZONTAL STACK)

RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 7000B

Filters : K24-K120

A.G.C. : WB

Gain Initial : -60

Final : -20

Geophones : HSJ 14c/s

Geophone pattern :



Shot-hole pattern :

PLAYBACK INFORMATION

Filters : 2/25 1/60

A.G.C. : Super Slow

Gain Initial : -40

Final : -10

Trip delay : 0·2 s

Compositing :

2 FOLD STACK
DOUBLE SUBSURFACE COVERAGE

VELOCITY INFORMATION

t:Δt

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1800 3600 FEET

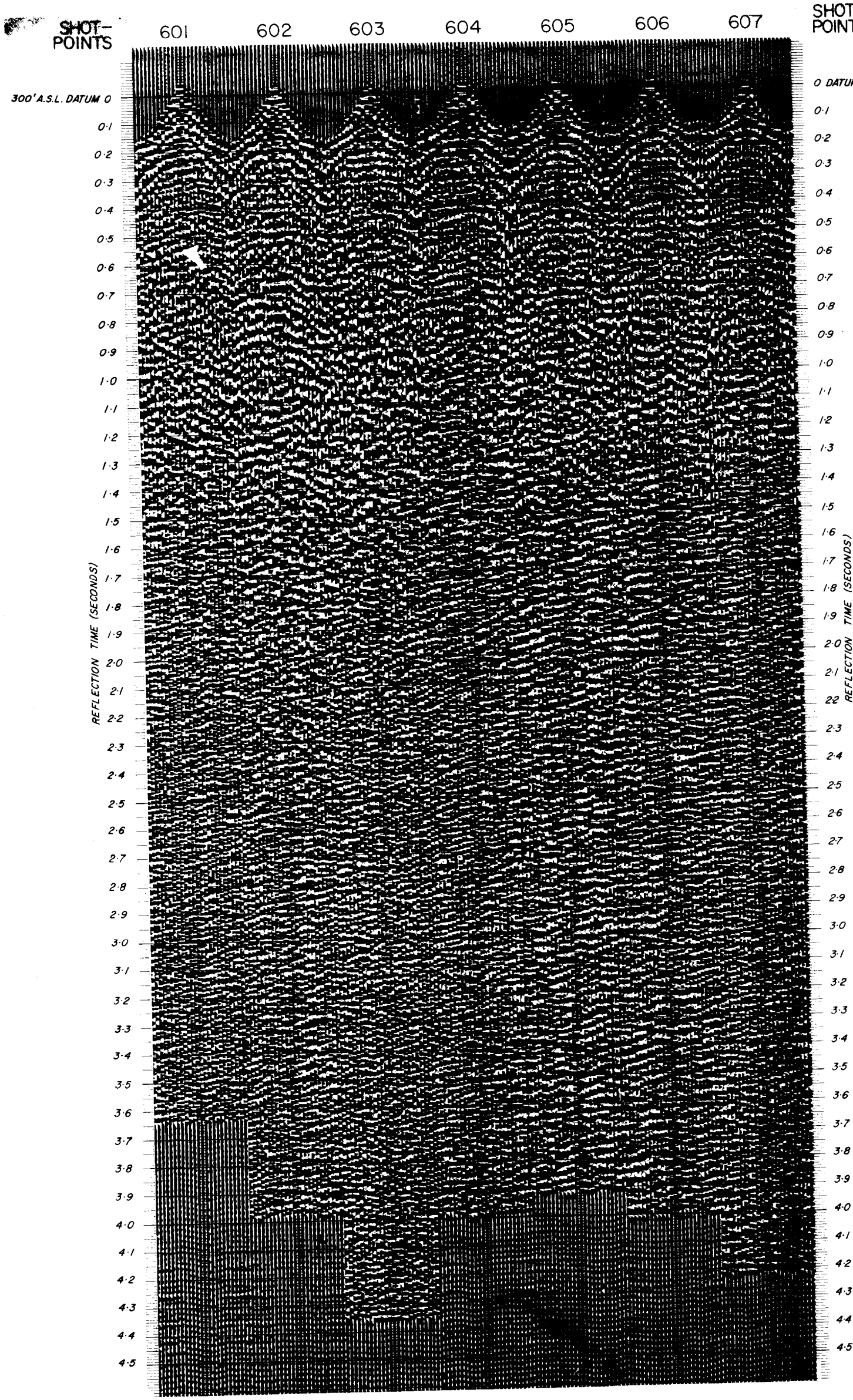
SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE A

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F54/183-95

TO ACCOMPANY RECORD No.1967/90



CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7 – 7

Amplifiers : 7000 B

Filters : K18 – K160

A.G.C. : W.B.

Gain Initial : –55

Final : –10

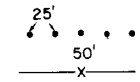
Geophones : HSJ – 14 c/s

Geophone pattern :

16/trace, 10' apart in line 50'

Station interval 150'

Shot-hole pattern :



Depth 45'

Charge 2½ to 5 lb/hole

PLAYBACK INFORMATION

Filters : 1/20 – 1/60

A.G.C. : S.S.

Gain Initial : –40

Final : –20

Trip delay : 0

Compositing : Nil

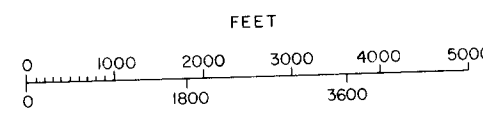
VELOCITY INFORMATION

t·Δt analysis and

Expanded Spread Velocity Shoot

Traverses E, U, W, T, H

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1963

TRAVERSE Q

RECORDED BY : *Seismic Party No.1*

SECTION BY : *Bureau of Mineral Resources*

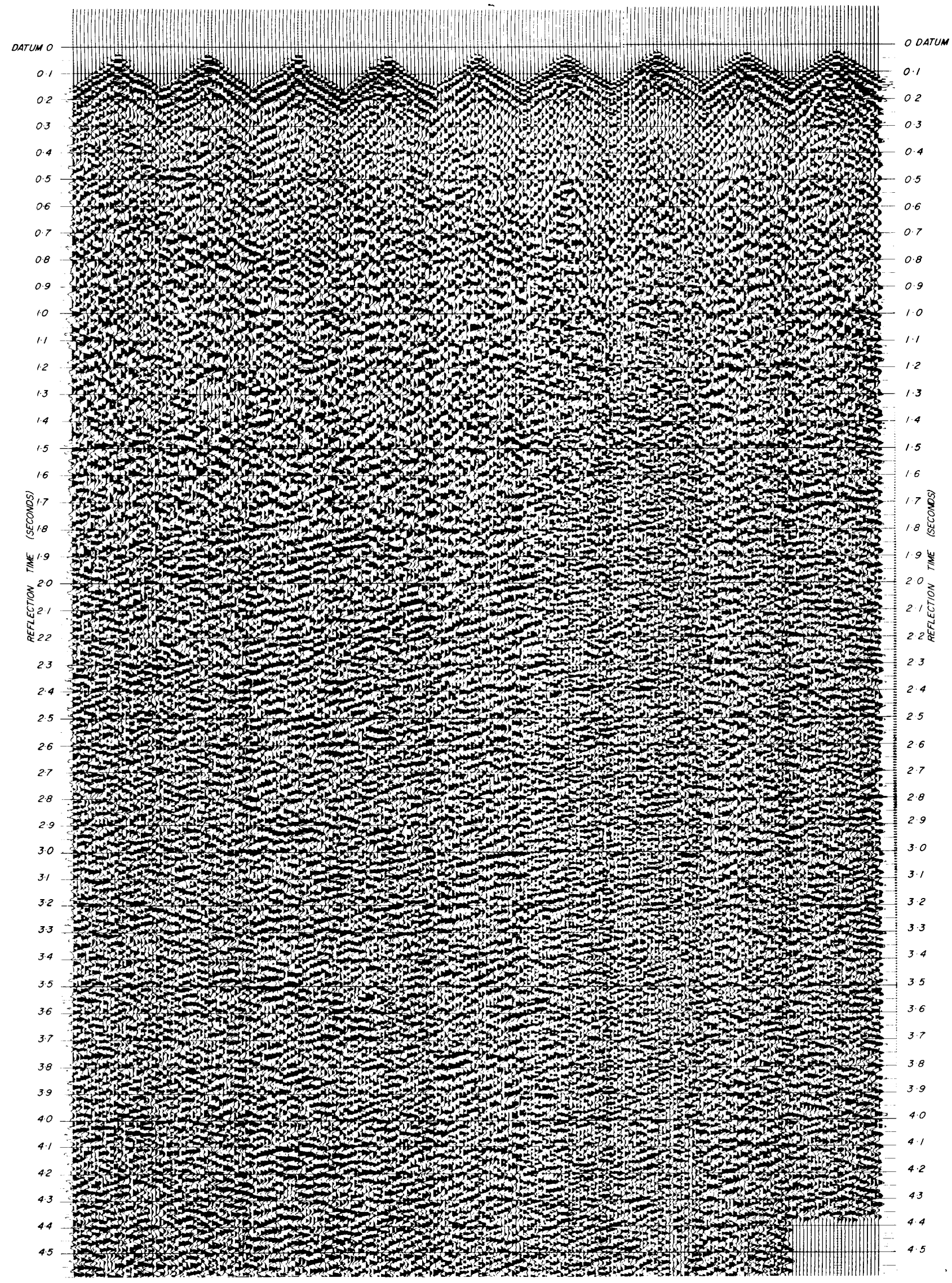
Playback Centre SIE MS 42

TO ACCOMPANY RECORD No. 1967/90

F54/B3-141

PLATE 30

UNCORRECTED RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder DS7-700

Amplifiers : 7000 B

Filters : K18-K120

A.G.C. : W.B.

Gain Initial : -55

Final : - 10

Geophones : HSJ - 14 c/s

Geophone pattern :

16 / trace, 10' apart in line

Station interval 150'

Shot-hole pattern :

SP6101 -6103 • 23' • • • • • Depth 60'

50' X Charge 7x2½ lb

SP6104 - 6109 Single, Depth 60', Charge 20 lb

PLAYBACK INFORMATION

Filters : 1/25 - 1/60

A.G.C. : S.S.

Gain Initial : -60

Final : -30

Trip delay : 0·2 s

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET

0 1800 3600

SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE N

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F54/B3-105

TO ACCOMPANY RECORD No. 1967/90

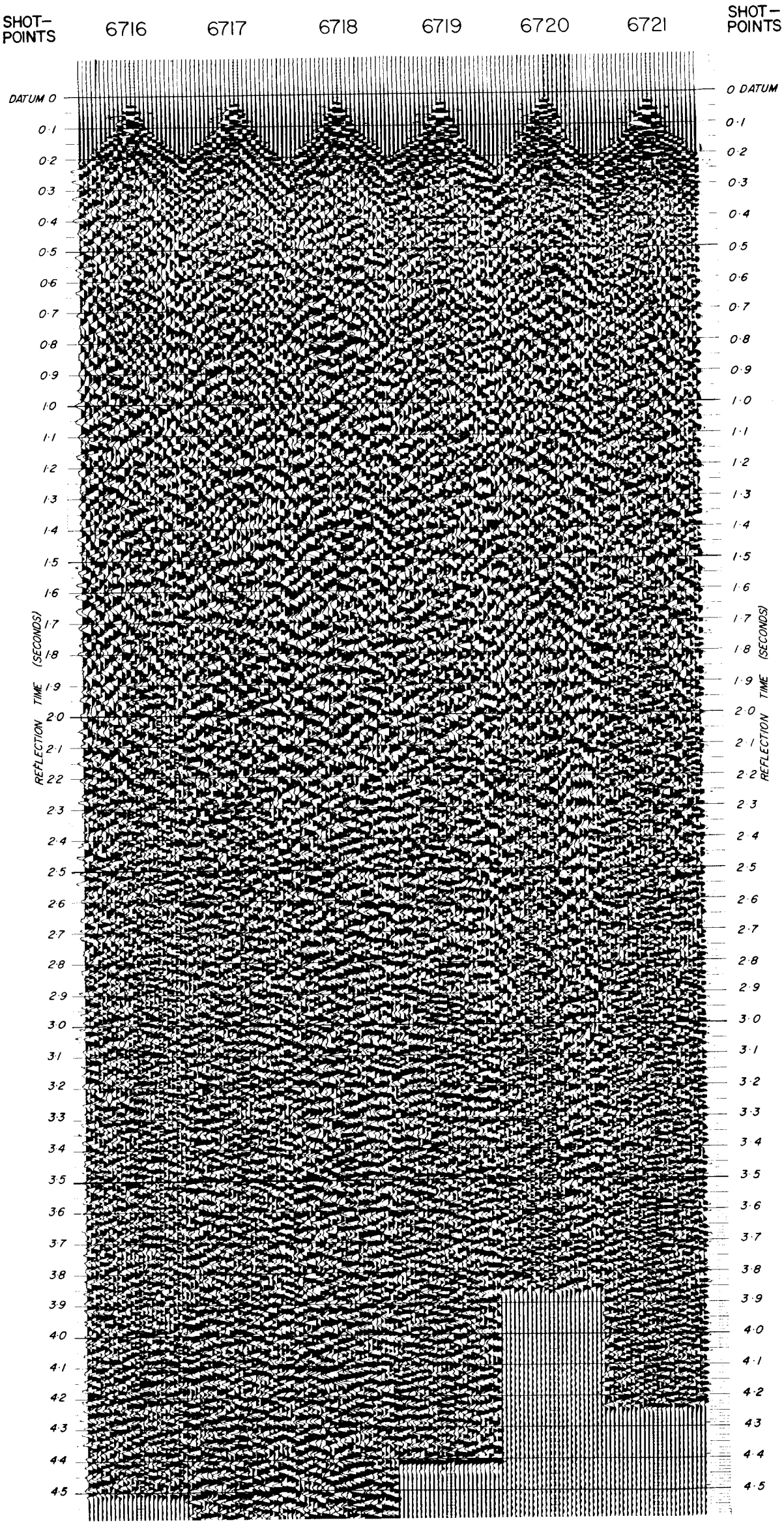


PLATE 31

UNCORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: DS7-700

Amplifiers: 7000 B

Filters: K18-K120

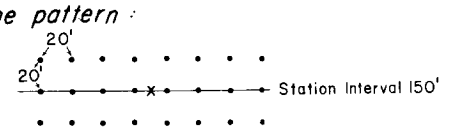
A.G.C.: W.B.

Gain Initial: -50,-55

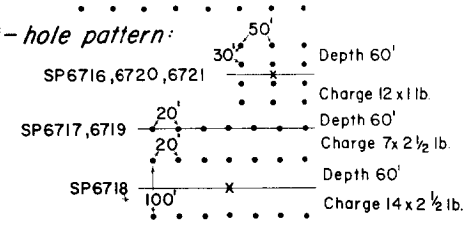
Final: - 10

Geophones: HSJ - 14 c/s

Geophone pattern:



Shot-hole pattern:



PLAYBACK INFORMATION

Filters: 1/25 - 1/60

A.G.C.: S.S.

Gain Initial: -60

Final: -30

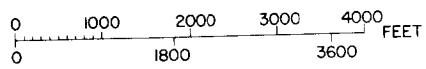
Trip delay: 0·2 s

Compositing: Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1964

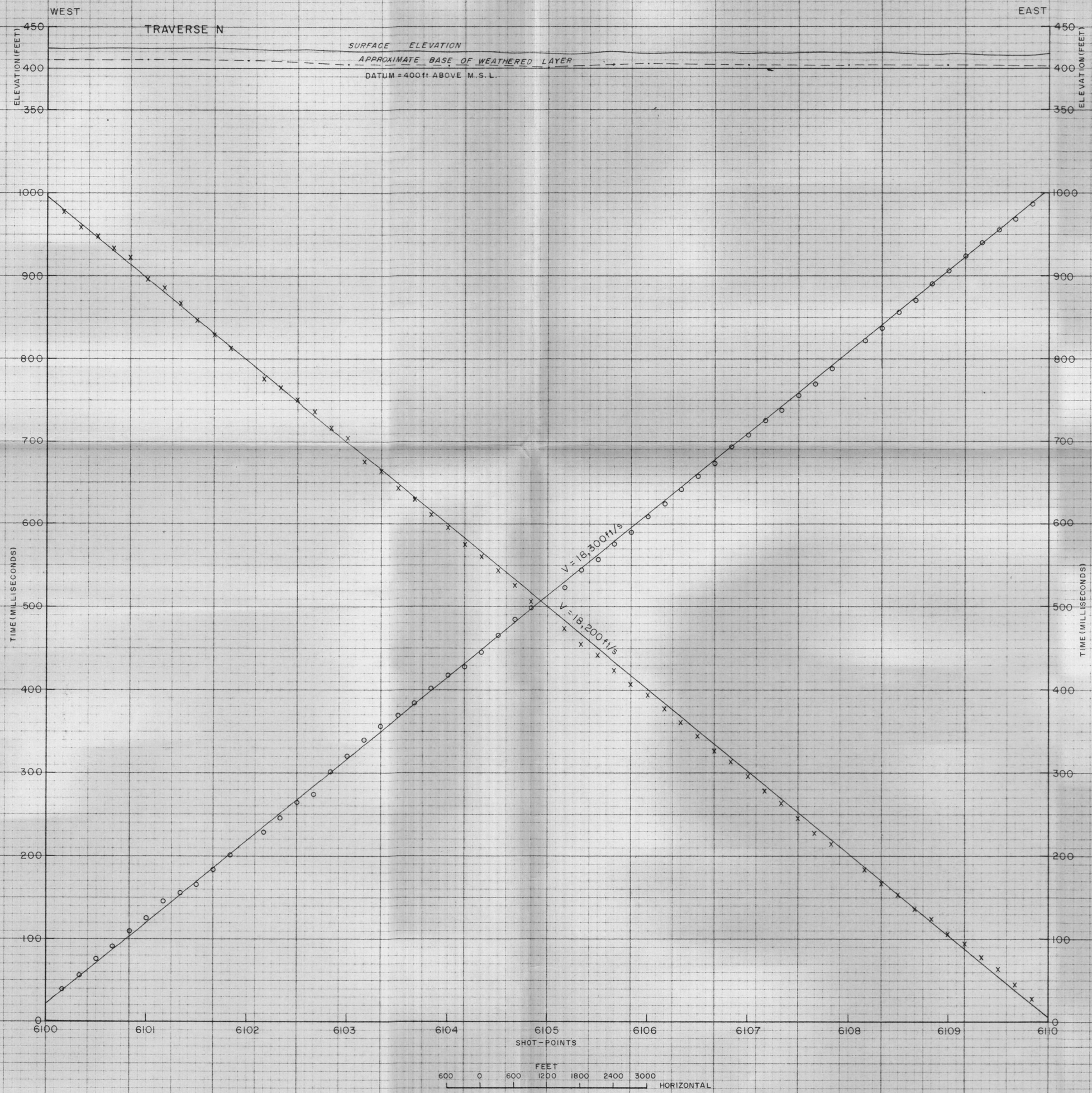
TRAVERSE R

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F54/B3-104

TO ACCOMPANY RECORD No 1967/90

PLATE 32



SP 6100

to	–	44	61	80	96	114	129	150	160	171	188	206	–	234	250	269	281	306	326	348	364	377	392	410	424
Wc+Ec	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	6	6	6
tc	–	40	57	76	92	110	125	146	156	167	184	202	–	230	246	265	276	301	321	343	359	372	386	404	418
	6100						6101						6102						6103						6104

SP 6100

to	328	346	363	376	390	408	426	437	454	473	491	506	–	531	551	564	581	596	–	627	645	661	677	698	714
Wc+Ec	7	7	7	8	8	8	8	8	8	7	7	7	7	7	6	6	5	5	4	4	4	4	5	5	5
tc	321	339	356	368	382	400	418	429	446	466	484	499	–	524	545	558	576	591	–	623	641	657	672	693	709
	6103						6104						6105						6106						6107

SP 6100

to	612	630	647	663	680	698	712	729	743	762	775	793	–	827	843	861	875	892	910	927	943	959	973	992	–
Wc+Ec	3	3	3	4	4	4	4	4	4	5	5	5	5	5	5	4	4	3	3	3	3	3	4	4	4
tc	609	627	644	659	676	694	708	725	739	757	770	788	–	822	838	857	871	889	907	924	940	956	969	988	–
	6106						6107						6108						6109						6110

SP 6110

to	397	380	363	349	331	316	300	282	266	250	232	218	–	186	172	155	139	126	108	95	80	65	47	30	–
Wc+Ec	2	2	2	3	3	3	3	3	3	4	4	4	4	4	4	3	3	2	2	2	2	2	3	3	3
tc	395	378	361	346	328	313	297	279	263	246	228	214	–	182	168	152	136	124	106	93	78	63	44	27	–
	6106						6107						6108						6109						6110

SP 6110

to	712	695	674	654	642	622	607	588	573	555	538	517	–	483	464	451	432	415	402	386	370	352	336	321	305
Wc+Ec	11	11	11	11	12	12	12	12	12	12	11	11	11	11	10	10	9	9	8	8	8	8	9	9	9
tc	701	684	663	643	630	610	595	576	561	543	527	506	–	472	454	441	423	406	394	378	362	344	327	312	296
	6103						6104						6105						6106						6107

SP 6110

to	1008	984	965	954	938	927	902	890	873	852	835	818	–	783	771	756	744	724	713	693	671	648	639	620	608
Wc+Ec	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	8	8	8
tc	1002	978	959	948	932	921	896	884	867	846	829	812	–	777	765	750	737	717	706	686	664	641	631	612	600
	6100						6101						6102						6103						6104

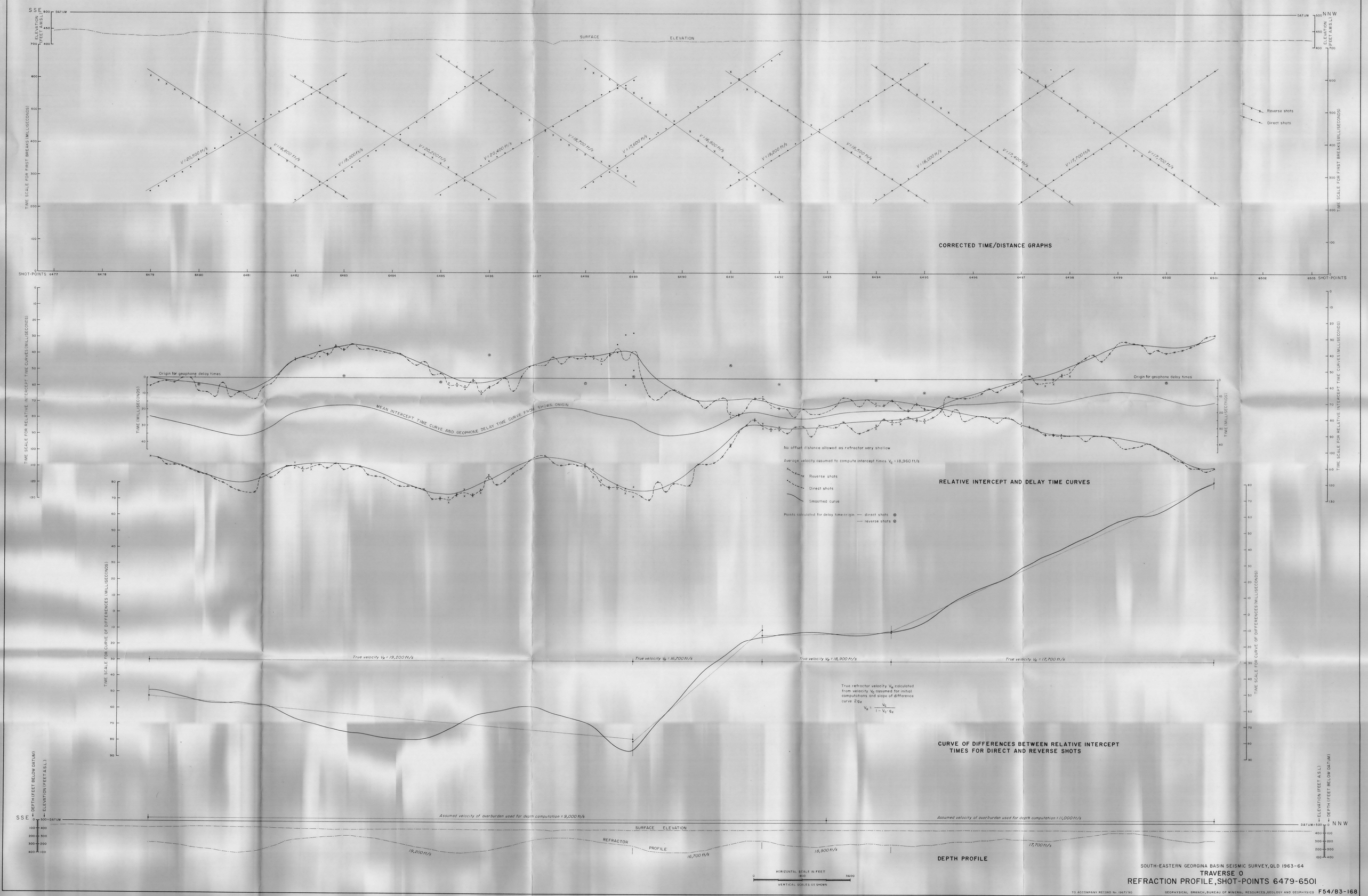
SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963-64

TRAVERSE N

REFRACTION TIME/DEPTH PLOT

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS **F54/B3-166**



CORRECTED TIME/DISTANCE GRAPHS

RELATIVE INTERCEPT AND DELAY TIME CURVES

CURVE OF DIFFERENCES BETWEEN RELATIVE INTERCEPT TIMES FOR DIRECT AND REVERSE SHOTS

DEPTH PROFILE

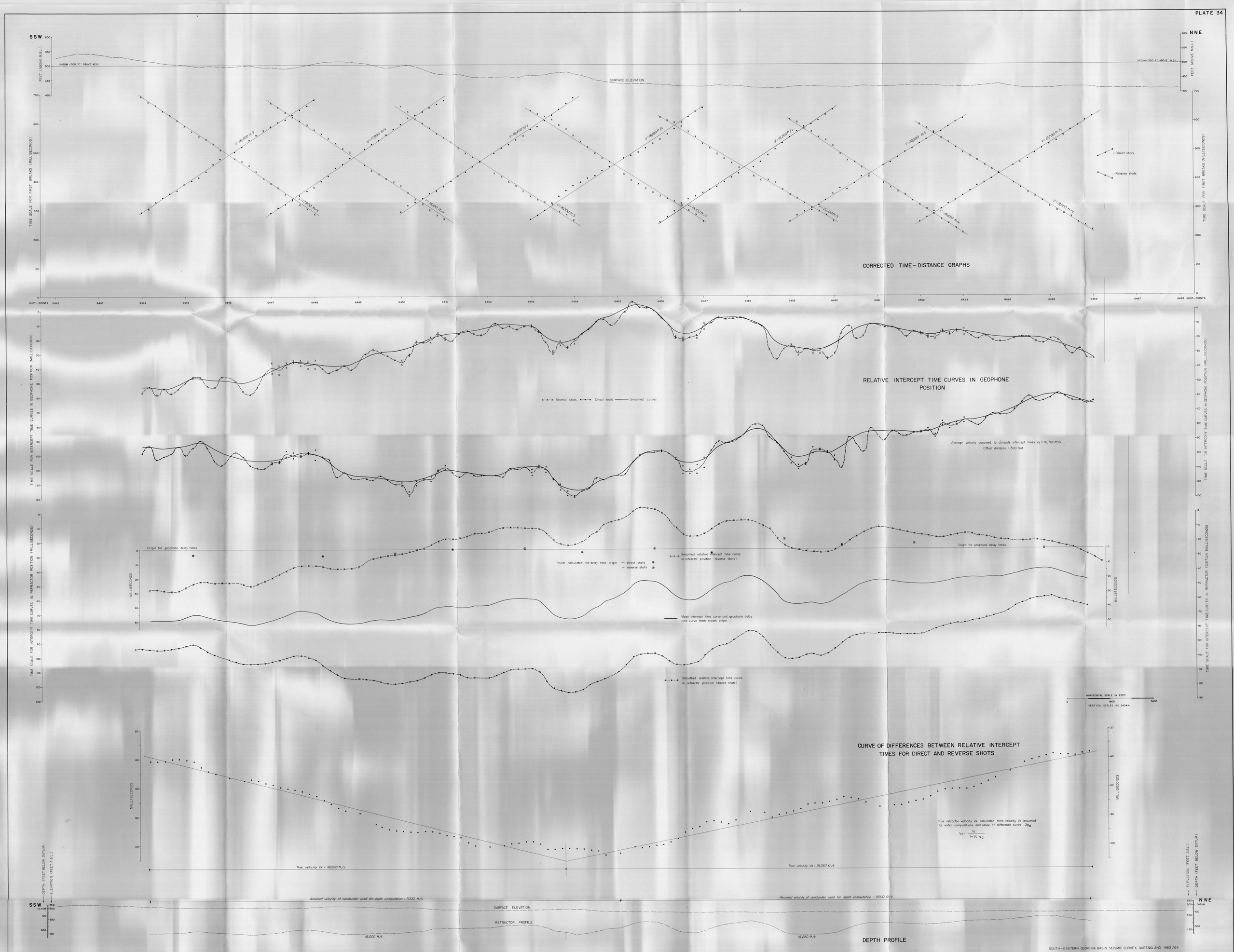
SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963-64

TRAVERSE 0

REFRACTION PROFILE, SHOT-POINTS 6479-6501

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-168



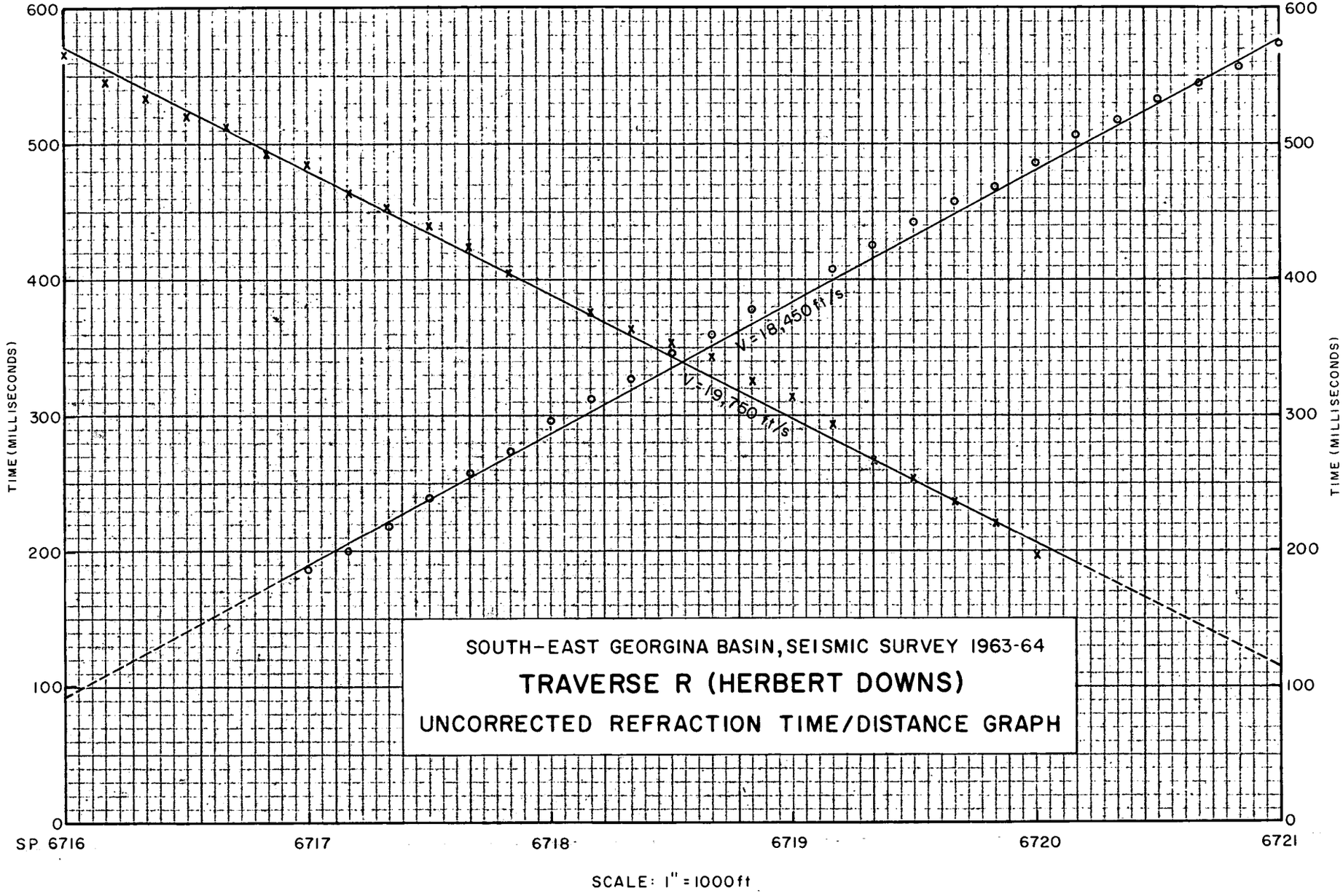
SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QUEENSLAND 1963/64

TRAVERSE O

REFRACTION PROFILE, SHOT-POINTS 6444-6466

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-167



TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-120

PLATE 35

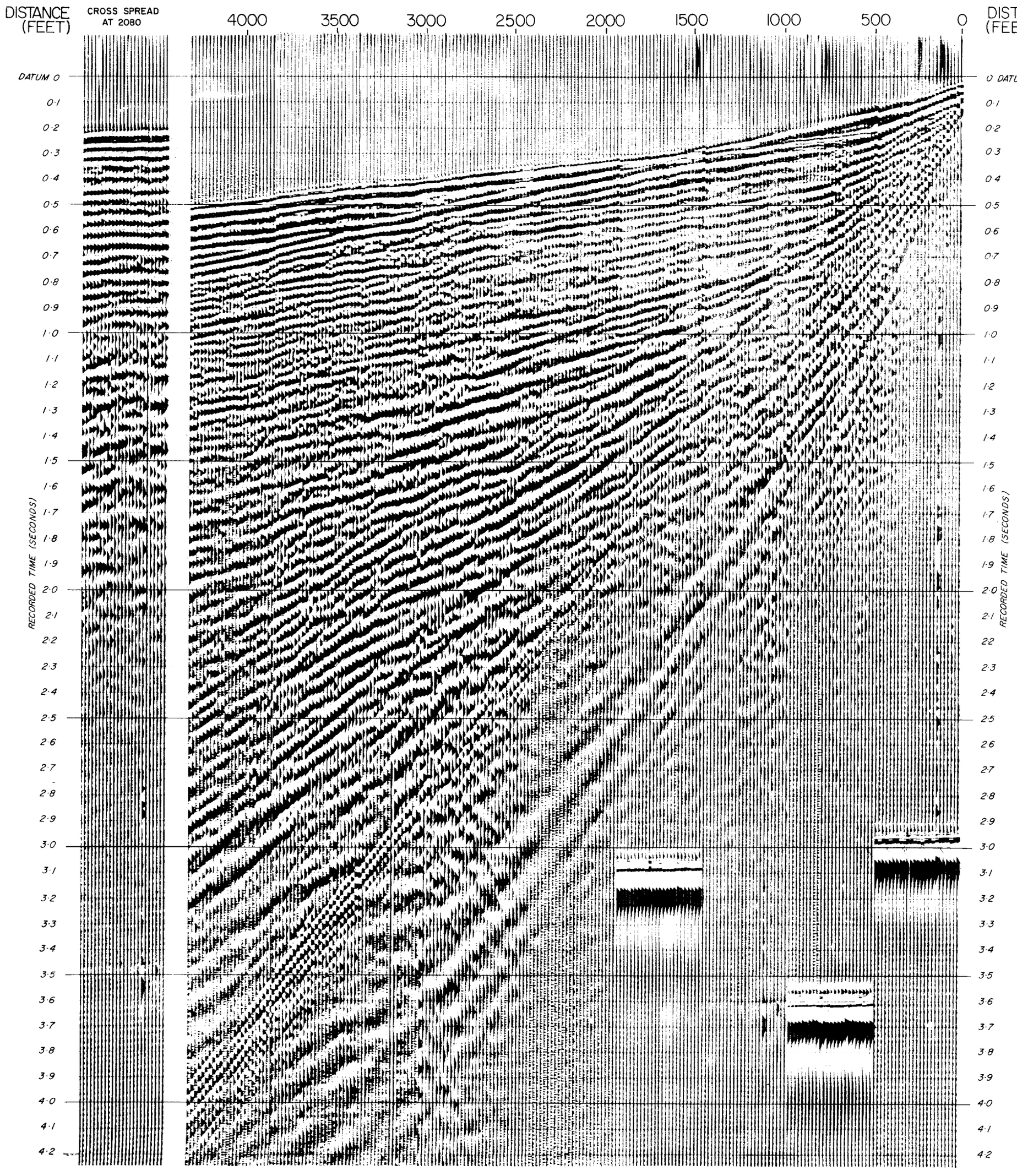


PLATE 36

RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 7000 B

Filters : Nil

A.G.C. : Nil

Gain Initial : CONSTANT

Final : −10, −20 or −30 dB

Geophones : T.I.C. 20 c/s

Geophone pattern :

Single

Station Interval 20'

Shot-hole pattern :

Single

Depth 45'

Charge 2½ lb

PLAYBACK INFORMATION

Filters : Nil

A.G.C. : S

Gain Initial : −50

Final : −30

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

FEET

0 500 1000

0 480 960

SOUTH-EASTERN GEORGINA BASIN

SEISMIC SURVEY, 1964

TRAVERSE V

NOISE ANALYSIS SP7783

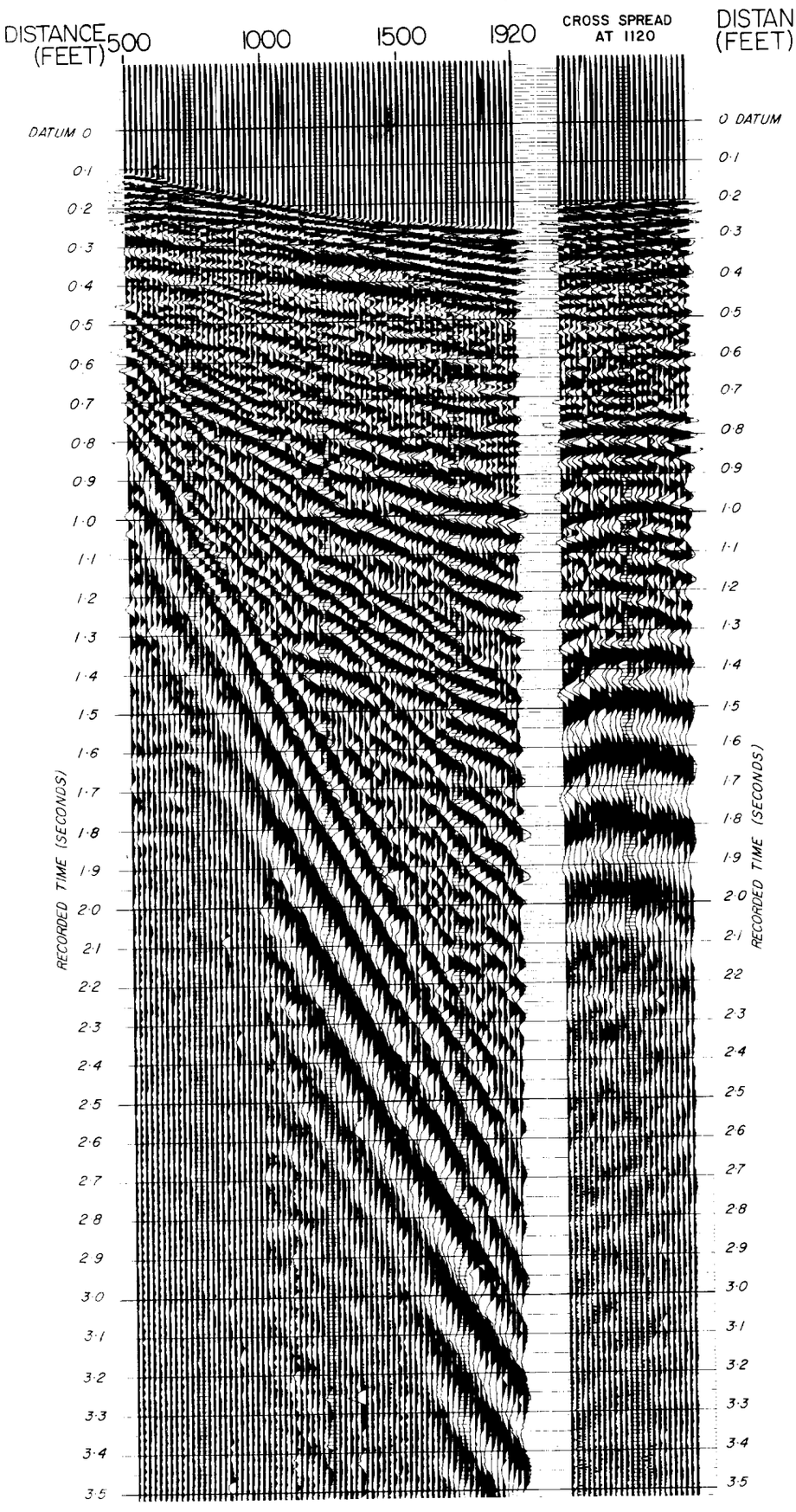
RECORDED BY : *Seismic Party No.1*

SECTION BY : *Bureau of Mineral Resources*

Playback Centre SIE MS 42

F54/B3-165

TO ACCOMPANY RECORD No.1967/90



PLATE

RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 7000 B

Filters : OUT

A.G.C. : Nil

Gain Initial :

Final : CONSTANT −50, −40, 3 : dB

Geophones : T.I.C. 20 c/s

Geophone pattern :

Single

Station Interval 20'

Shot-hole pattern :

Single

Depth 40'

Charge 2½ lb

PLAYBACK INFORMATION

Filters : Nil

A.G.C. : S

Gain Initial : −50

Final : −30

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

FEET

0 500 1000

0 480 960

SOUTH-EASTERN GEORGINA BASIN

SEISMIC SURVEY, 1964

TRAVERSE V

NOISE ANALYSIS SP7676

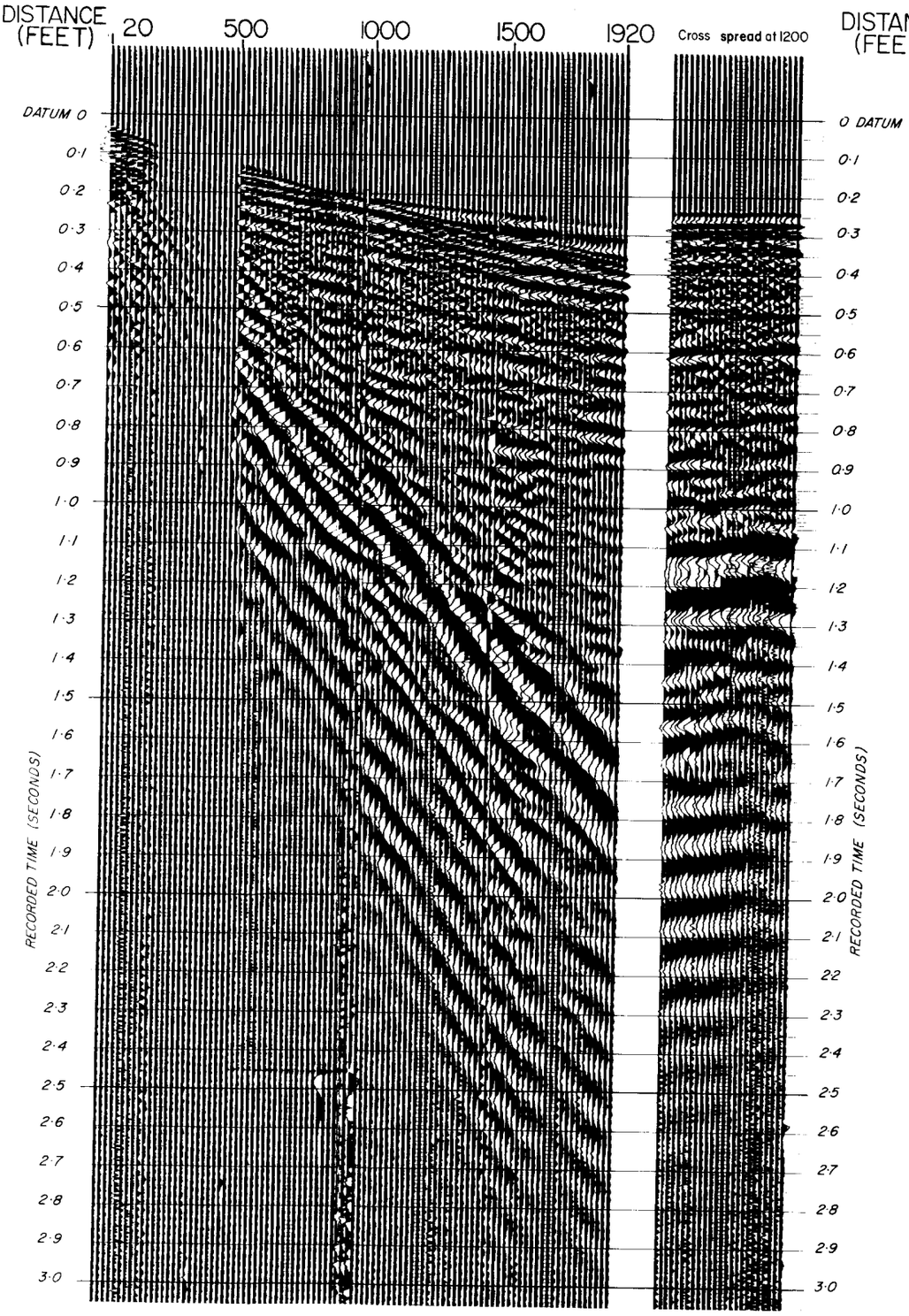
RECORDED BY : *Seismic Party No.1*

SECTION BY : *Bureau of Mineral Resources*

Playback Centre SIE MS 42

TO ACCOMPANY RECORD No. 1967/30

F54/B3-164



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7 – 7

Amplifiers : 7000B

Filters : Nil

A.G.C. : Nil

Gain Initial :

Final : Linear – 20

Geophones : T.I.C. 20c/s

Geophone pattern :

Single geophones

Shot-hole pattern :

Single

Depth 30'

PLAYBACK INFORMATION

Filters : Nil

A.G.C. : S

Gain Initial : –40

Final : –30

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

As shown

SOUTH-EASTERN GEORGINA BASIN 1963

TRAVERSE A

NOISE ANALYSIS SP 1007

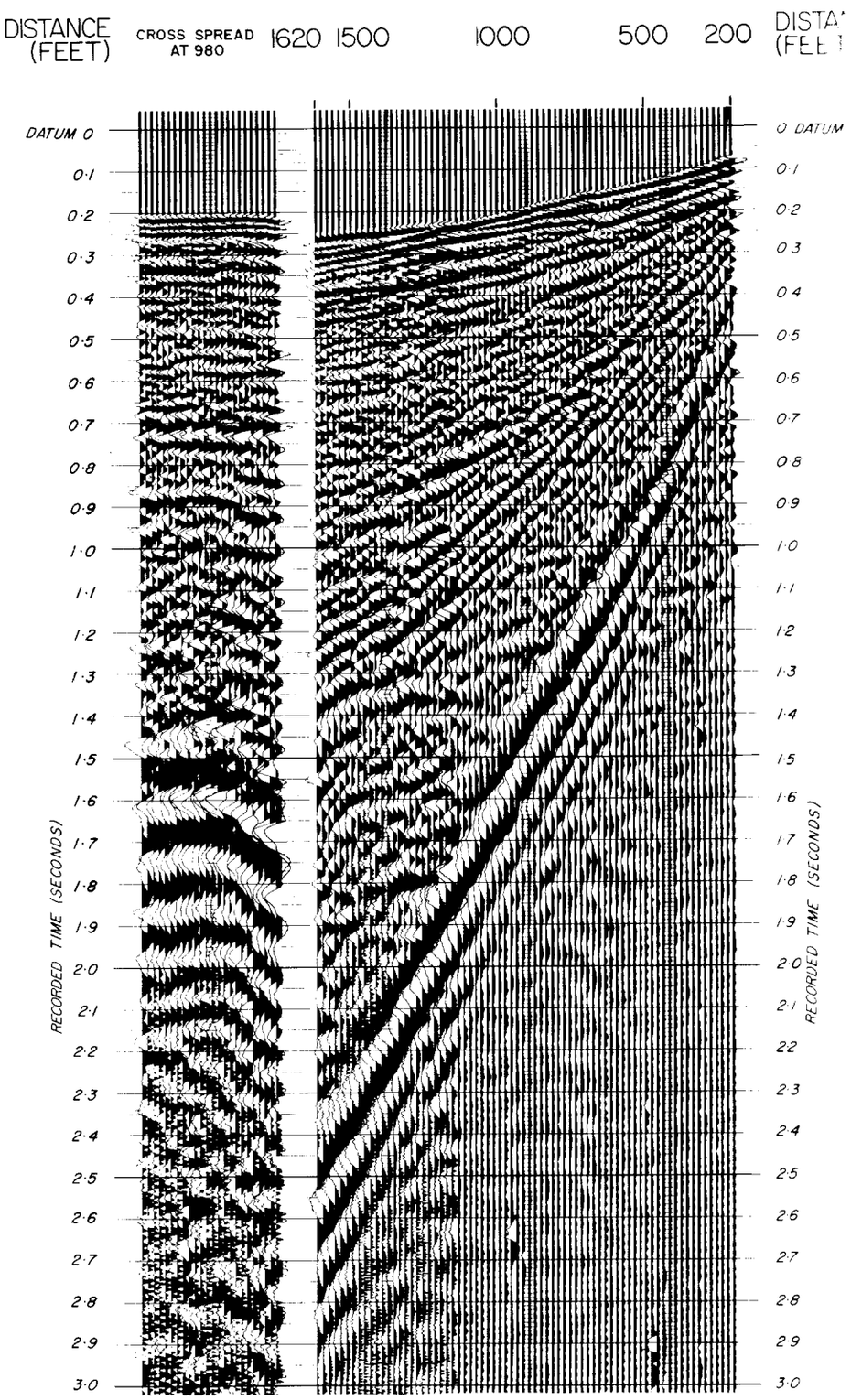
RECORDED BY : *Seismic Party No.1*

SECTION BY : *Bureau of Mineral Resources*

Playback Centre SIE MS 42

TO ACCOMPANY RECORD No. 1967/90

F54/B3-160



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7–7

Amplifiers : 7000 B

Filters : Nil

A.G.C. : Nil

Gain Initial :
Final : LINEAR –30 to –60 dB

Geophones : T.I.C. 20 c/s

Geophone pattern :
Single
Station Interval 20'

Shot-hole pattern :
Single
Depth 60' deep
Charge 7½ lb

PLAYBACK INFORMATION

Filters : Nil

A.G.C. : S

Gain Initial : –60

Final : –30

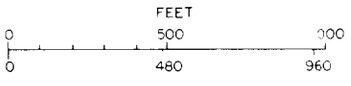
Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY, 1964

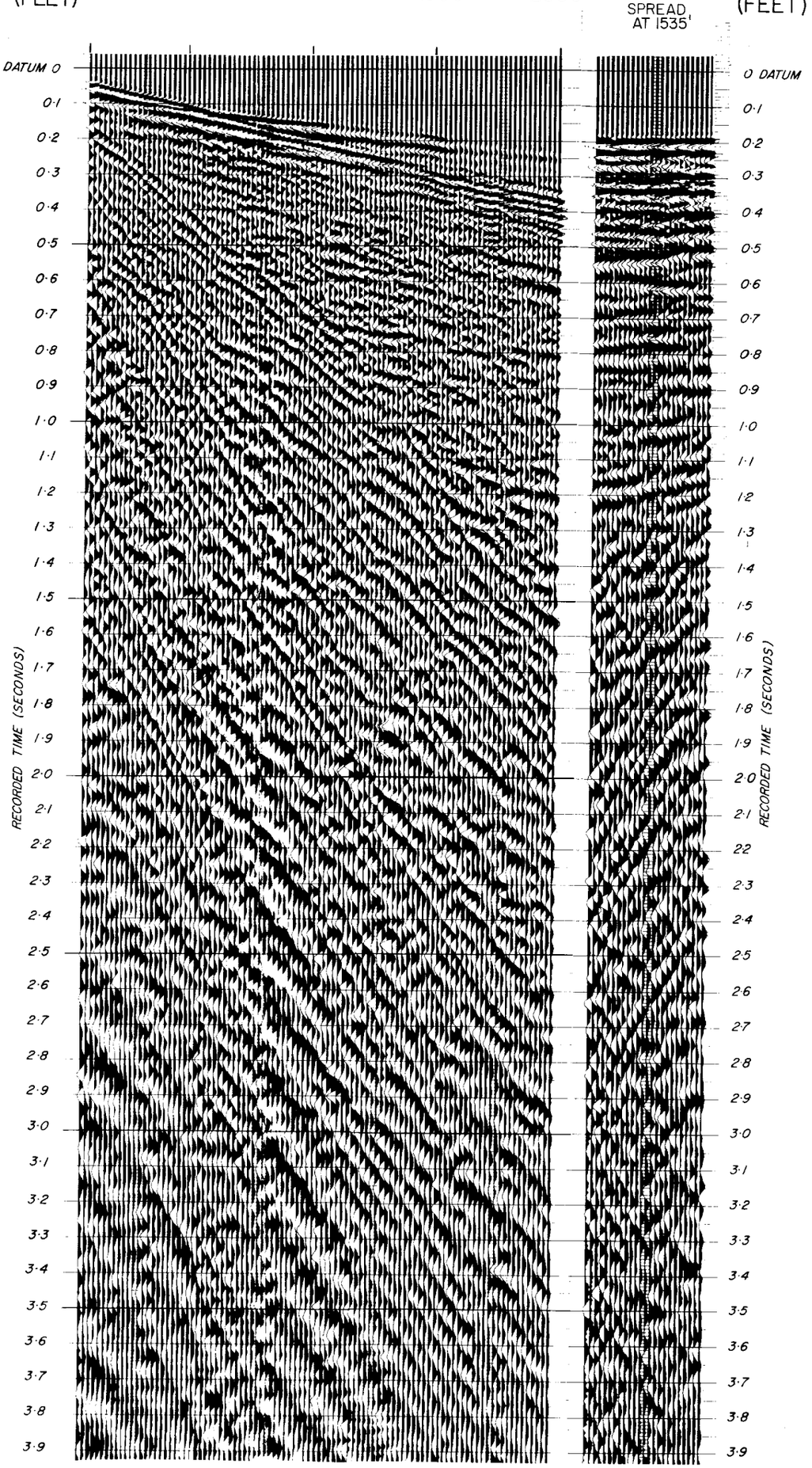
TRAVERSE A
NOISE ANALYSIS SP927

RECORDED BY : *Seismic Party No.1*

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

TO ACCOMPANY RECORD No 1967/90

F54/B3–163



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7–7

Amplifiers : 7000 B

Filters : Nil

A.G.C. : W.B.

Gain Initial : –70

Final : –50

Geophones : T.I.C. 20 c/s

Geophone pattern :
Single
Station Interval 20'

Shot-hole pattern :
Single holes
Depth 60'
Charge 5 lb

PLAYBACK INFORMATION

Filters : Nil

A.G.C. : S

Gain Initial : –50

Final : –30

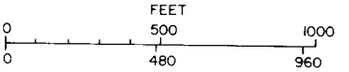
Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, 1964

TRAVERSE R

NOISE ANALYSIS SP6718

RECORDED BY : *Seismic Party No.1*

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

TO ACCOMPANY RECORD No. 1967/90

F54/B3-161

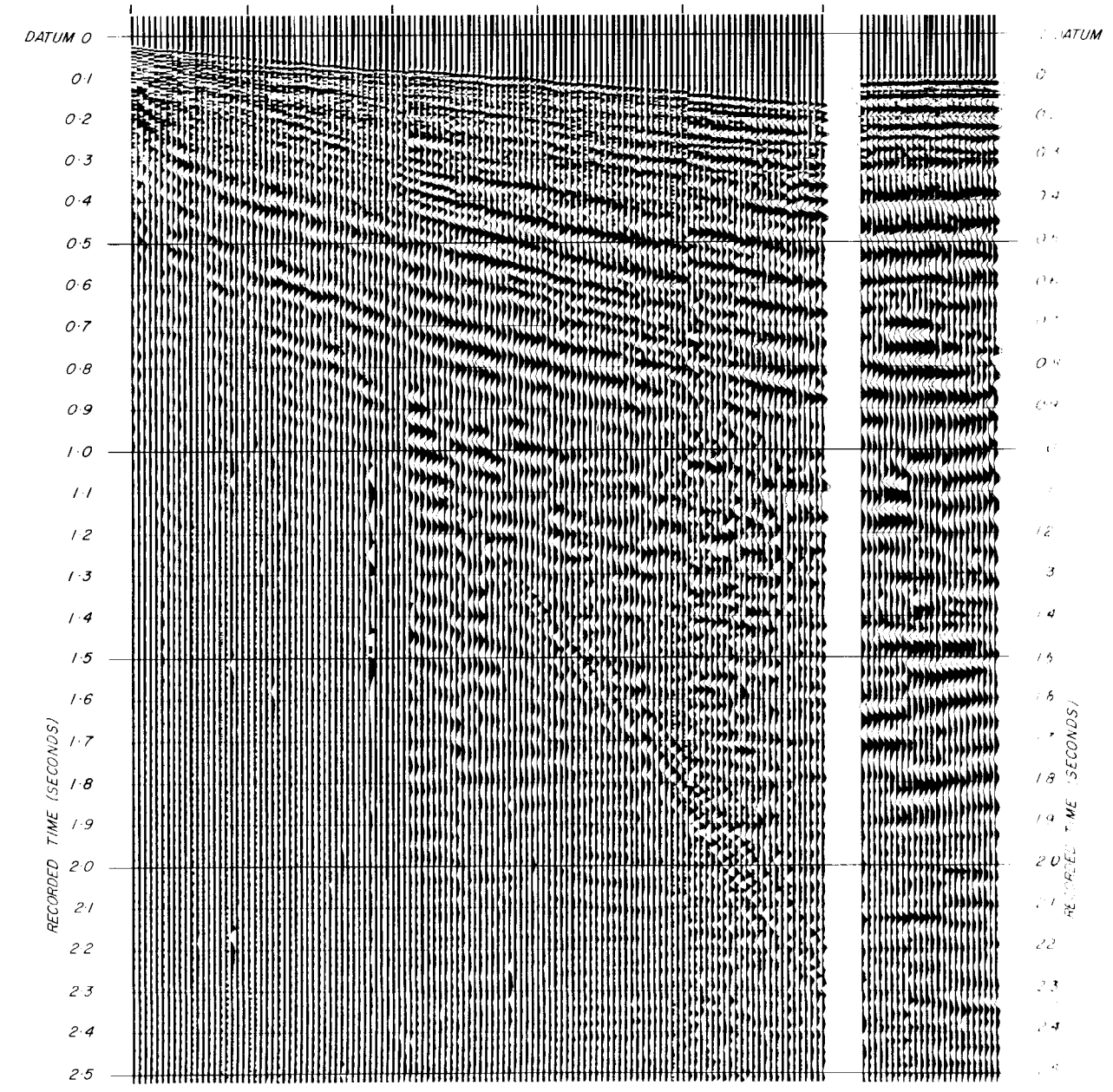


PLATE 41

RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7–7

Amplifiers : 7000 B

Filters : OUT

A.G.C. : Nil

Gain Initial : CONSTANT – 30dB

Final :

Geophones : T.I.C. 20 c/s

Geophone pattern :

Single

Station Interval 20'

Shot-hole pattern :

Single

Depth 30'

Charge ⅛ to 10lb

PLAYBACK INFORMATION

Filters : Nil

A.G.C. : S

Gain Initial : –50

Final : –30

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

FEET

0 500 1000

0 480 960

SOUTH-EASTERN GEORGINA BASIN

SEISMIC SURVEY, 1964

TRAVERSE N

NOISE ANALYSIS SP6105

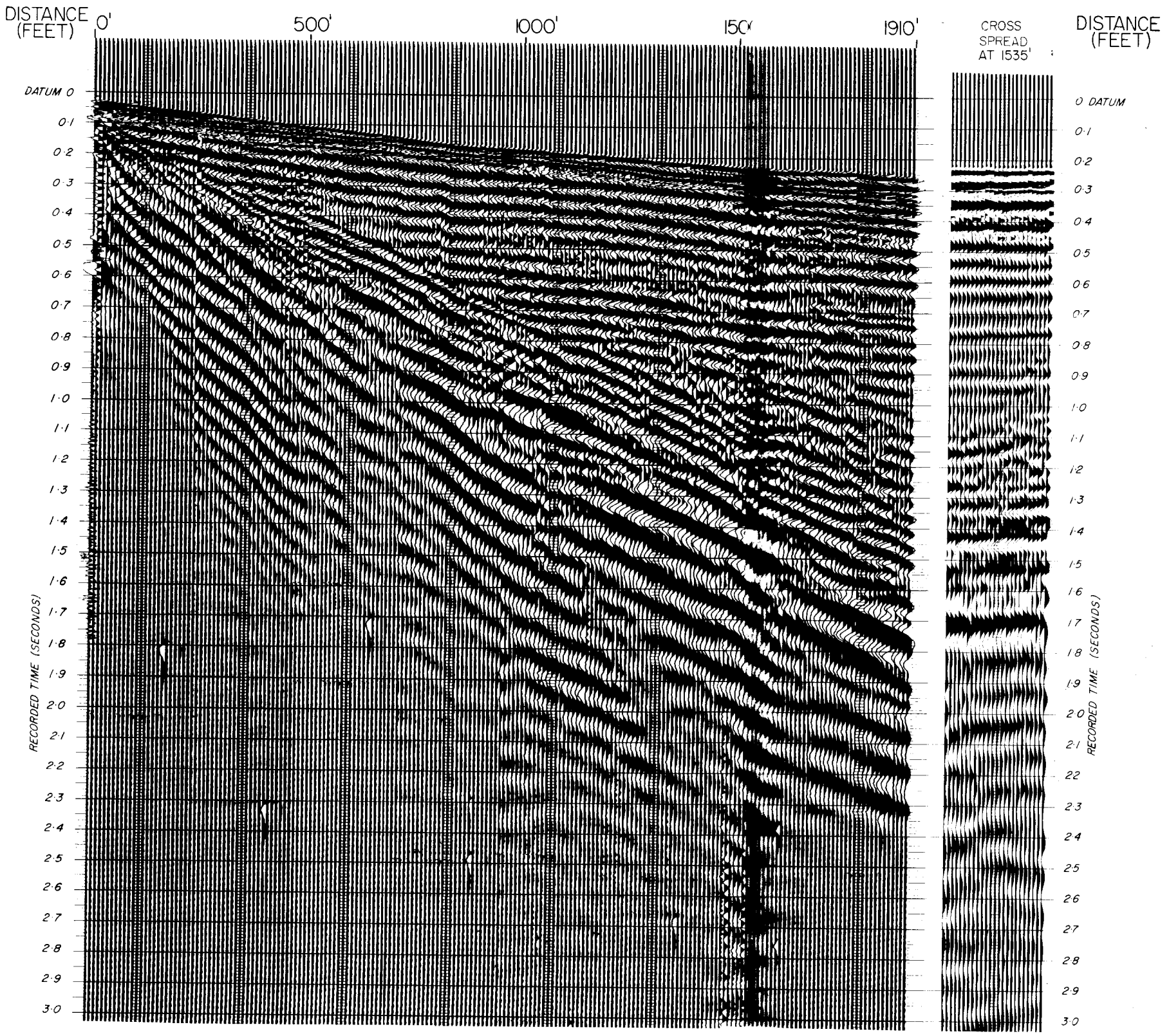
RECORDED BY : *Seismic Party No.1*

SECTION BY : *Bureau of Mineral Resources*

Playback Centre SIE MS 42

F54/B3–162

TO ACCOMPANY RECORD No 1967/90



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7–7

Amplifiers : 7000B

Filters : Nil

A.G.C. : Nil

Gain Initial : Linear – 30

Final :

Geophones : T.I.C. 20 c/s

Geophone pattern :

Single

Shot-hole pattern :

Single

Depth 30'

PLAYBACK INFORMATION

Filters : Nil

A.G.C. : S

Gain Initial : –50

Final : –30

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

As shown

SOUTH-EASTERN GEORGINA BASIN 1963

TRAVERSE F

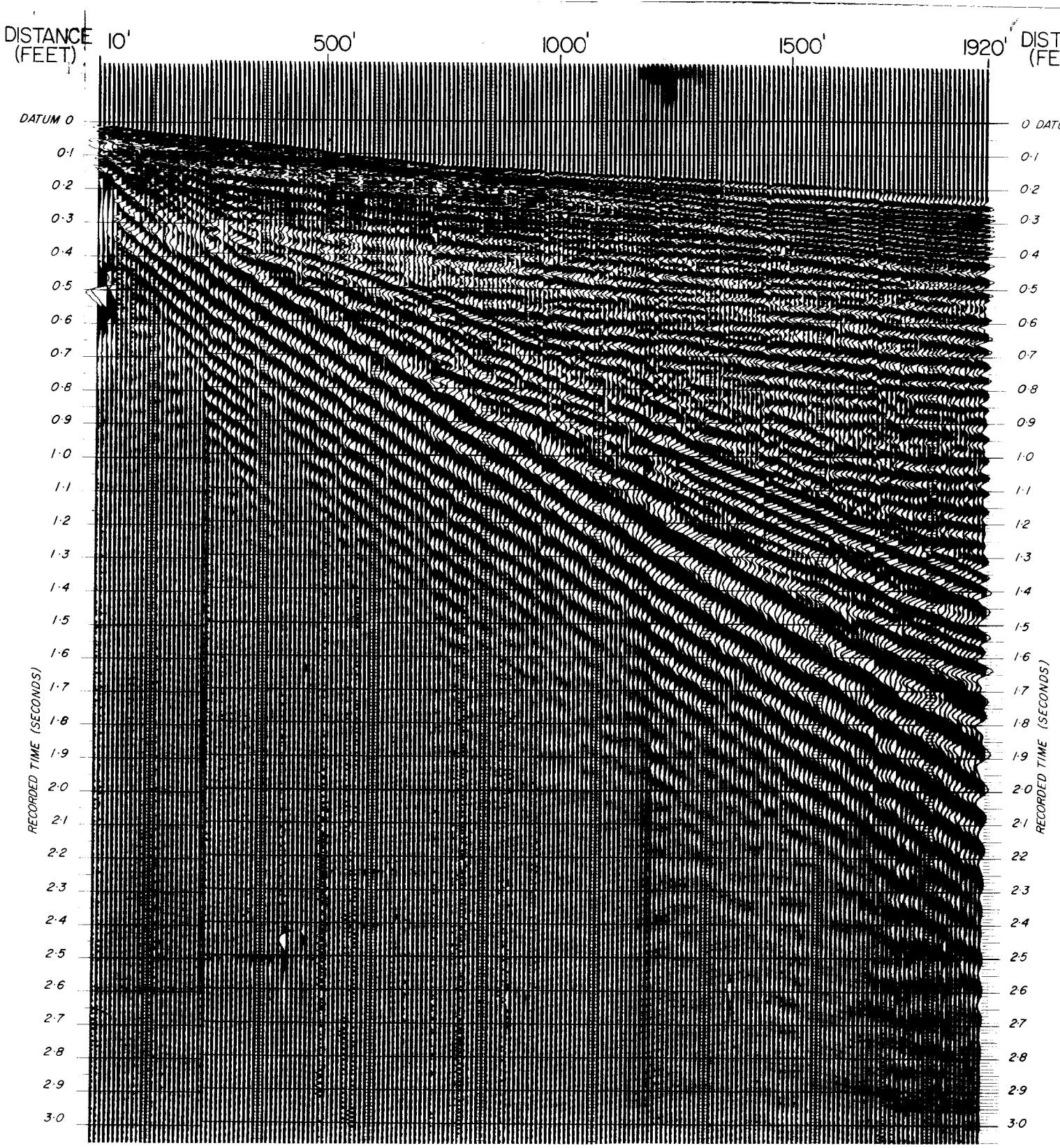
NOISE ANALYSIS SP206

TO ACCOMPANY RECORD No. 1967/90

RECORDED BY : *Seismic Party No. 1*

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

F54/B3–157



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7 – 7

Amplifiers : 7000 B

Filters : Nil

A.G.C. : Nil

Gain Initial : Linear – 30

Final :

Geophones : T.I.C. 20 c/s

Geophone pattern :

Single

Shot-hole pattern :

Single

Depth 30'

PLAYBACK INFORMATION

Filters : Nil

A.G.C. : S

Gain Initial : –40

Final : – 30

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

As shown

SOUTH-EASTERN GEORGINA BASIN 1963

TRAVERSE F

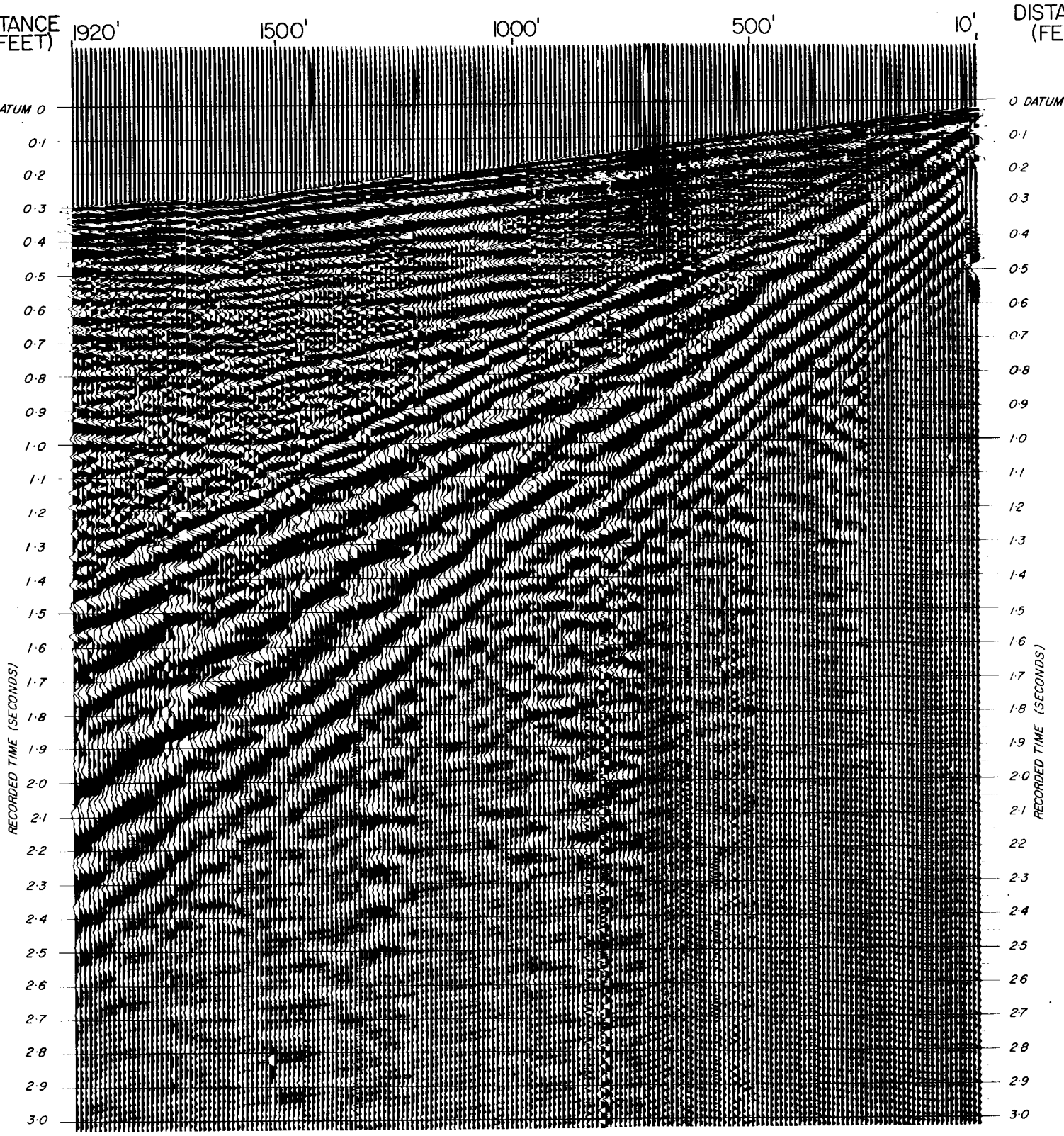
NOISE ANALYSIS SP 189

RECORDED BY : *Seismic Party No.1*

SECTION BY : *Bureau of Mineral Resources*

Playback Centre SIE MS 42

F54/B3 – 159



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7 – 7

Amplifiers : 7000 B

Filters : Nil

A.G.C. : Nil

Gain Initial : Linear – 30

Final : Linear – 30

Geophones : T.I.C. 20 c/s

Geophone pattern :

Single

Shot-hole pattern :

Single

Depth 30'

PLAYBACK INFORMATION

Filters : Nil

A.G.C. : S

Gain Initial : –40

Final : –30

Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

As shown

SOUTH-EASTERN GEORGINA BASIN

1963

TRAVERSE F

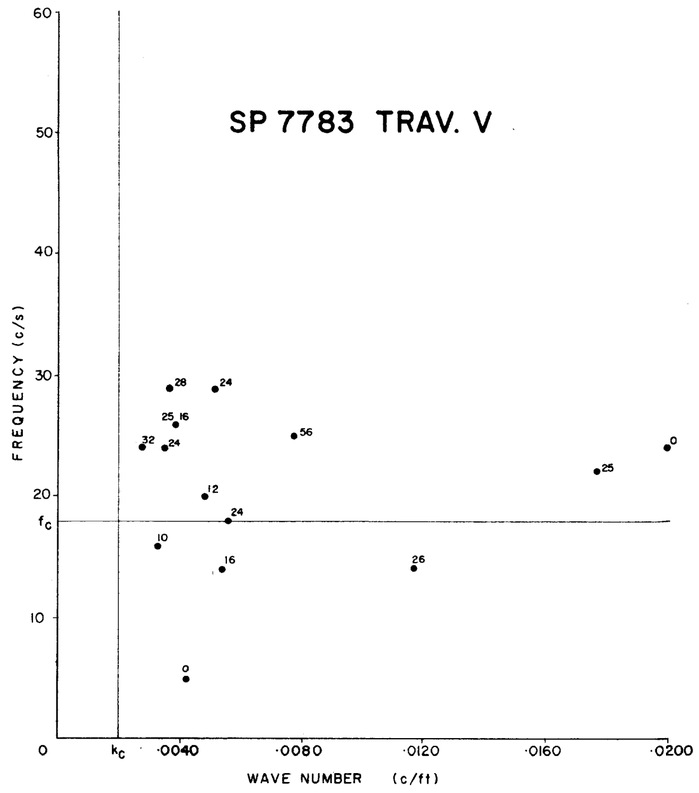
NOISE ANALYSIS SP178

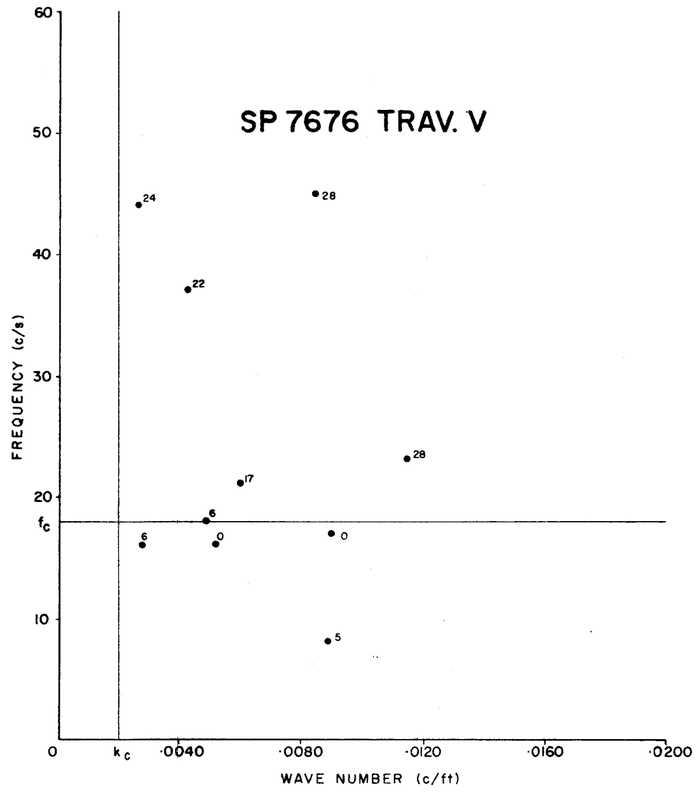
RECORDED BY : *Seismic Party No.1*

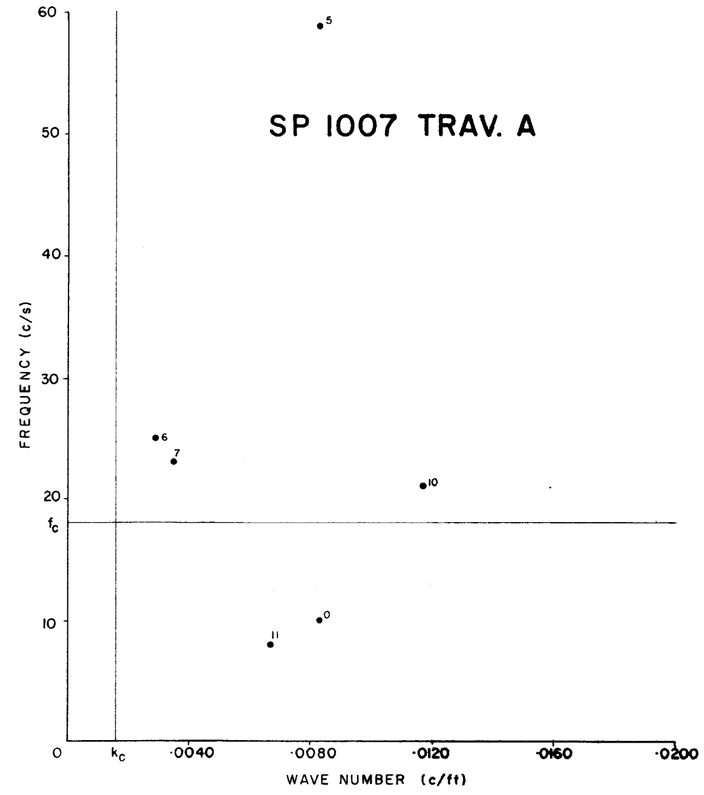
SECTION BY : *Bureau of Mineral Resources*

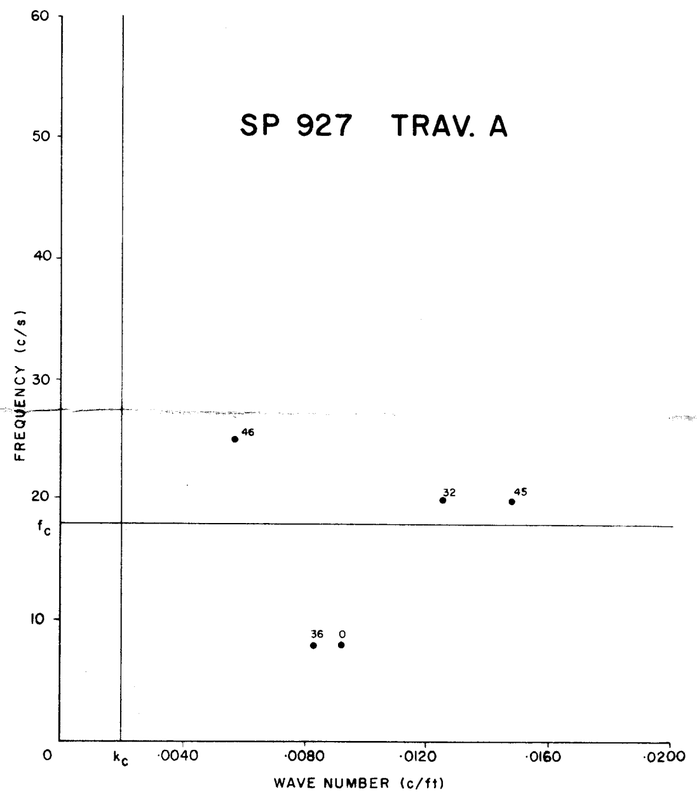
Playback Centre SIE MS 42 F54/B3–158

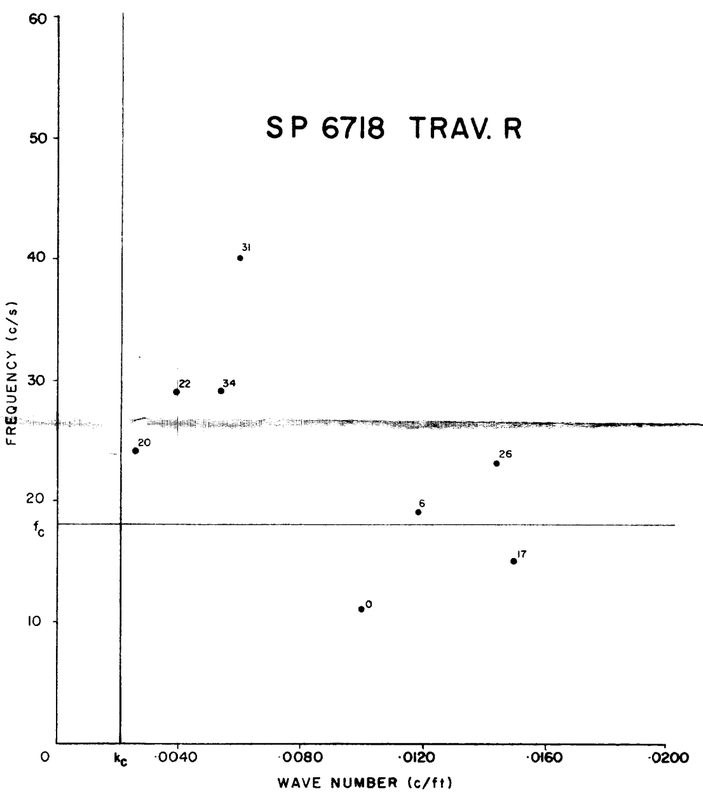
COMPANY RECORD No. 1967/90

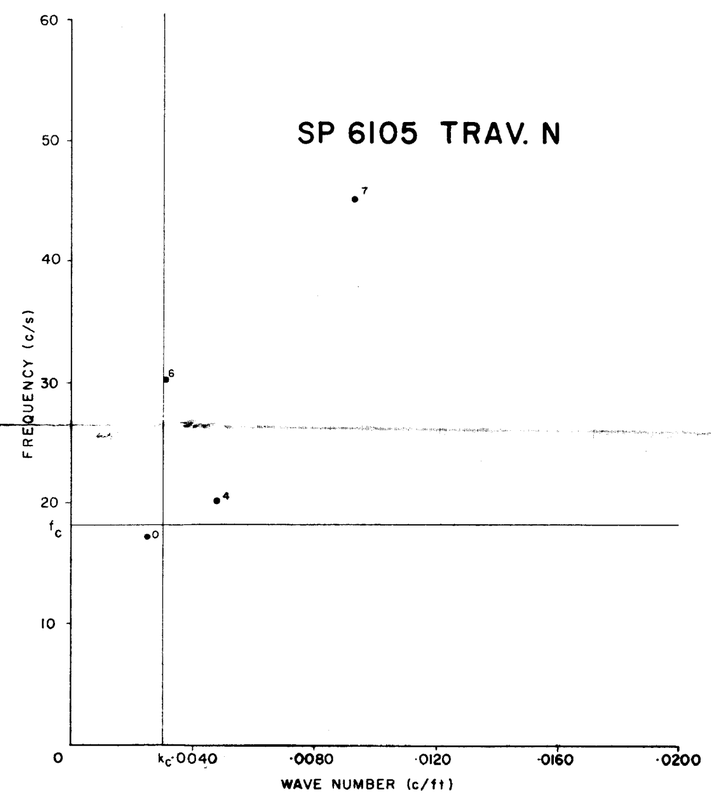


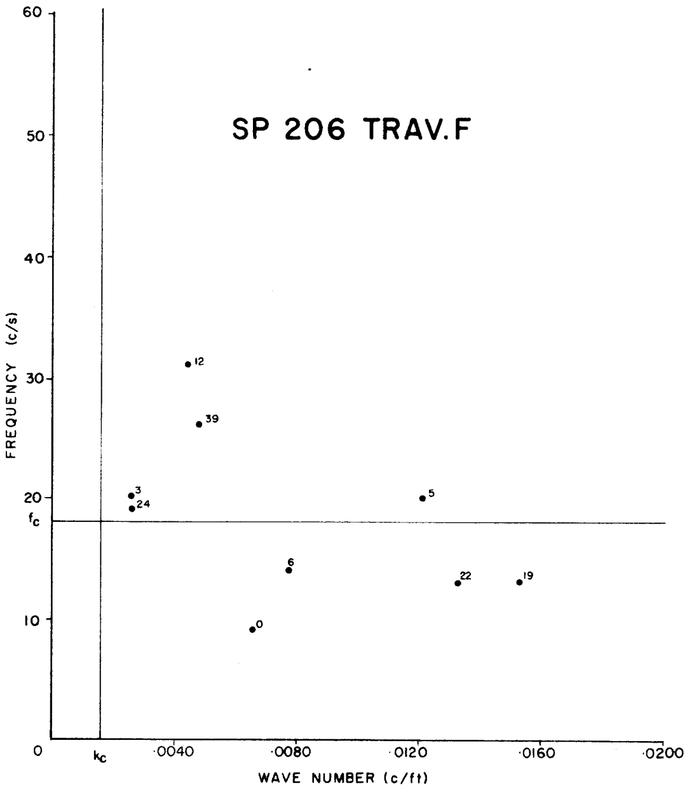


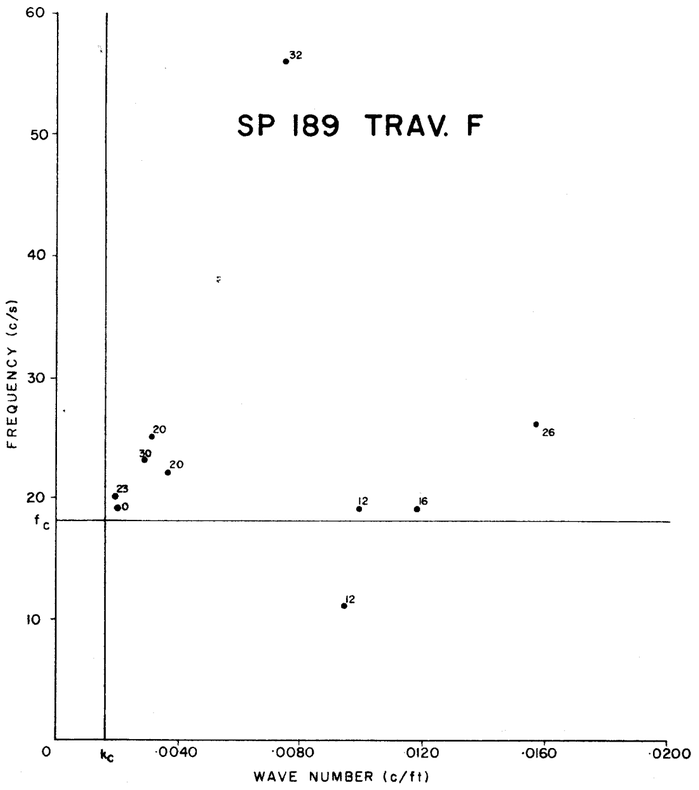


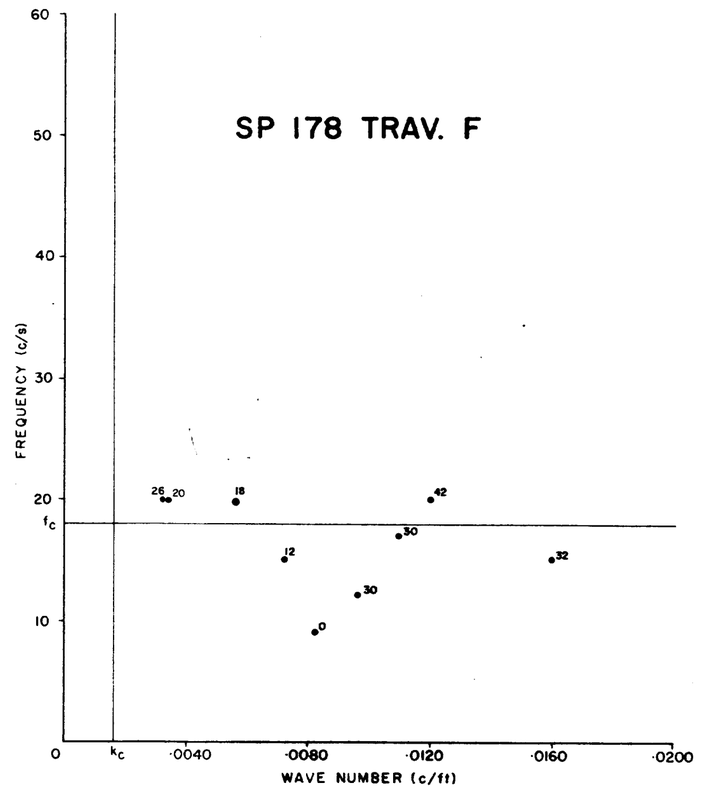












LEGEND

•18 Figures indicate relative amplitudes in decibels above amplitude of weakest coherent noise event.

f_c is the cut-off Frequency of the low-cut electrical filter used for recording reflections.

k_c is the cut-off wave number for spatial filtering by the geophone and shothole patterns used for recording reflections.
k_c is defined by $k_c = \frac{1}{2ne}$, where n = number of geophones or holes and e = spacing between geophones or holes in feet.

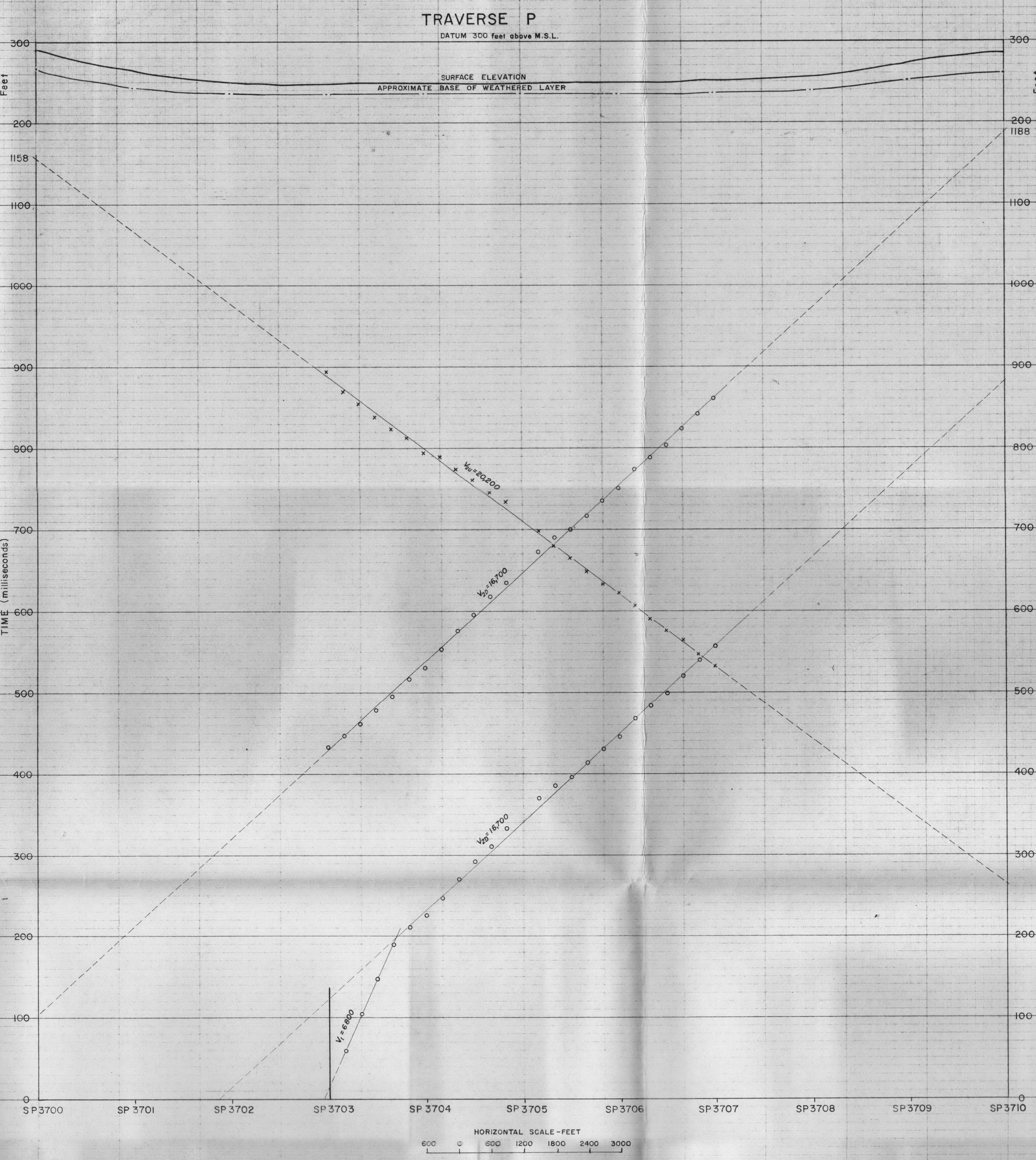
NOISE TESTS

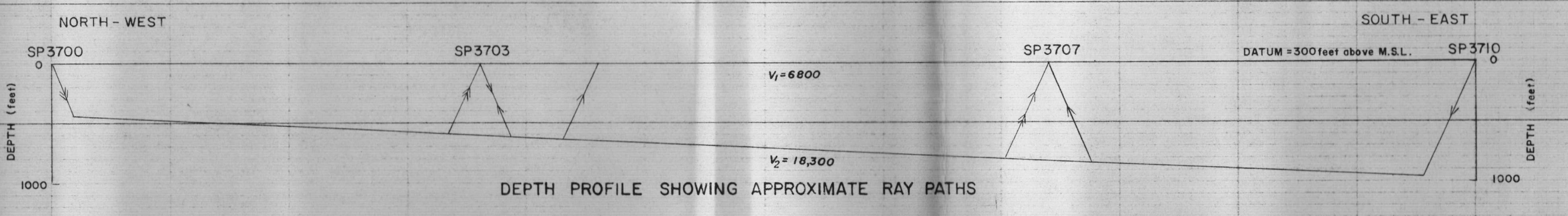
GRAPHS OF FREQUENCY AGAINST WAVE NUMBER FOR NOISE EVENTS RECORDED

TO ACCOMPANY RECORD No. 1967/90

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. F 54/B3–170

PLATE 46





DEPTH PROFILE SHOWING APPROXIMATE RAY PATHS

SP 3703

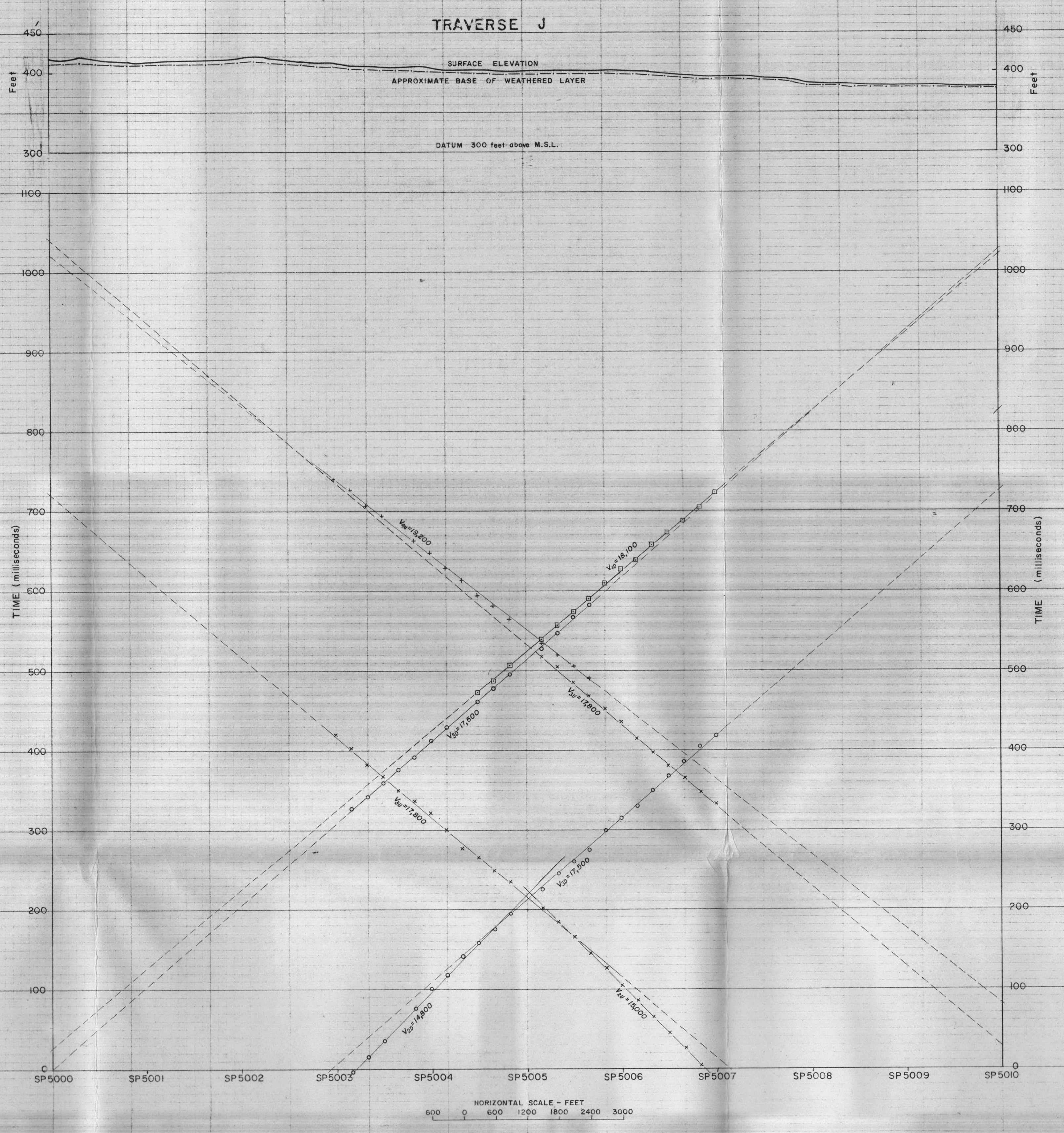
t_o	—	52	97	140	174	196	211	232	255	277	295	317	—	354	369	380	397	415	430	453	467	484	504	524	542
W_c+E_c	—	-8	-8	-8	-16	-16	-16	-16	-16	-16	-16	-16	—	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16
t_c	—	60	105	148	190	212	227	248	271	293	311	333	—	370	385	396	413	431	446	469	483	500	520	540	558
	3703						3704						3705						3706						3707

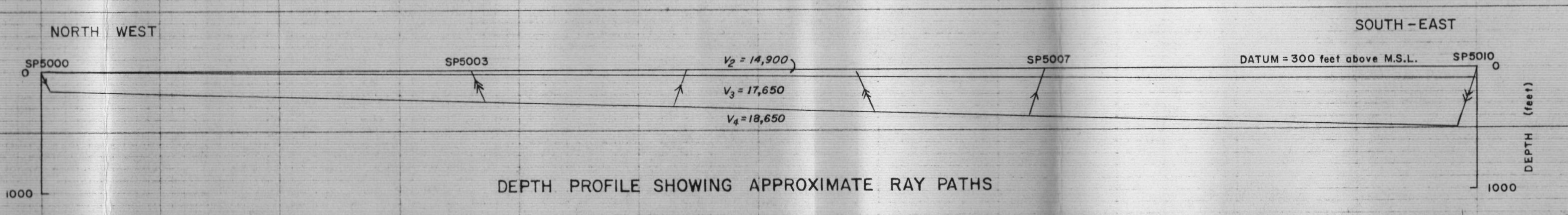
SP3700

t_o	423	438	452	469	487	507	521	543	567	586	608	625	—	663	680	690	707	726	740	764	779	794	814	832	851
W_c+E_c	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	—	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
t_c	433	448	462	479	497	517	531	553	577	596	618	635	—	673	690	700	717	736	750	774	789	804	824	842	861
	3703						3704						3705						3706						3707

SP 3710

t_o	883	860	844	829	813	802	784	779	764	750	735	723	—	689	670	655	639	622	612	597	580	565	553	537	522
W_c+E_c	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	—	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
t_c	893	870	854	839	823	812	794	789	774	760	745	733	—	699	680	665	649	632	622	607	590	575	563	547	532
	3703						3704						3705						3706						3707





DEPTH PROFILE SHOWING APPROXIMATE RAY PATHS

SP5003

t_o	—	30	50	68	—	109	133	151	174	190	206	226	—	257	277	292	307	331	347	361	381	399	417	436	449
W_c+E_c	33	33	33	32	32	32	32	32	32	31	31	31	31	31	31	31	31	31	31	31	31	31	31	30	30
t_c	—	-3	17	36	—	77	101	119	142	159	175	195	—	226	246	261	276	300	316	330	350	368	386	406	419
	5003						5004						5005						5006						5007

SP 5000

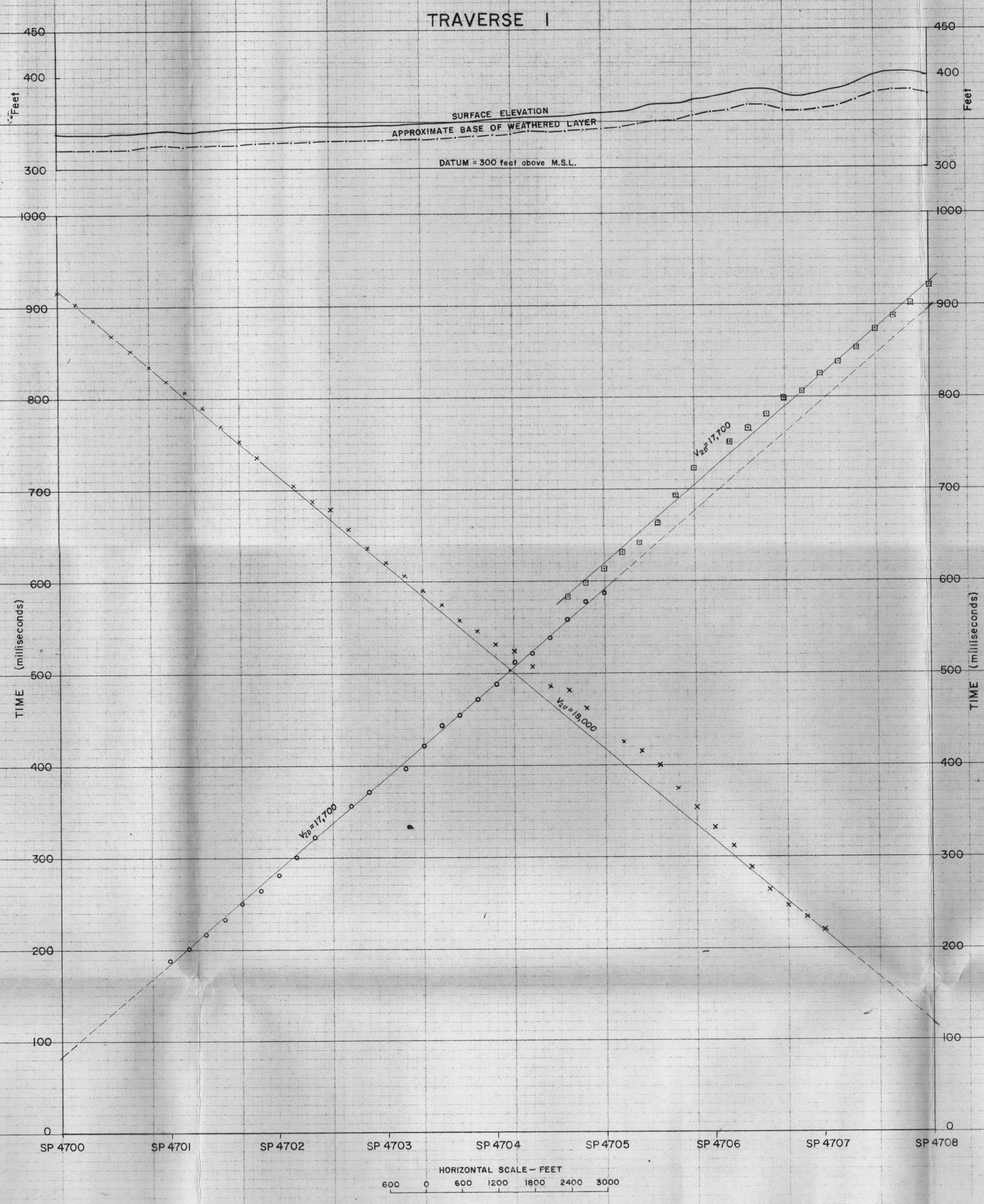
t_o	—	362	377	393	410	425	447	463	—	493 505	510 520	529 539	—	560 571	579 589	599 605	614 622	641	659	670	690	705	720	735	754
W_c+E_c	34	34	34	33	33	33	33	33	33	32	32	32	32	32	32	32	32	32	32	32	32	32	32	31	31
t_c	—	328	343	360	377	392	414	430	—	461 473	478 488	497 507	—	528 539	547 557	567 573	582 590	609	627	638	658	673	688	704	723
	5003						5004						5005						5006						5007

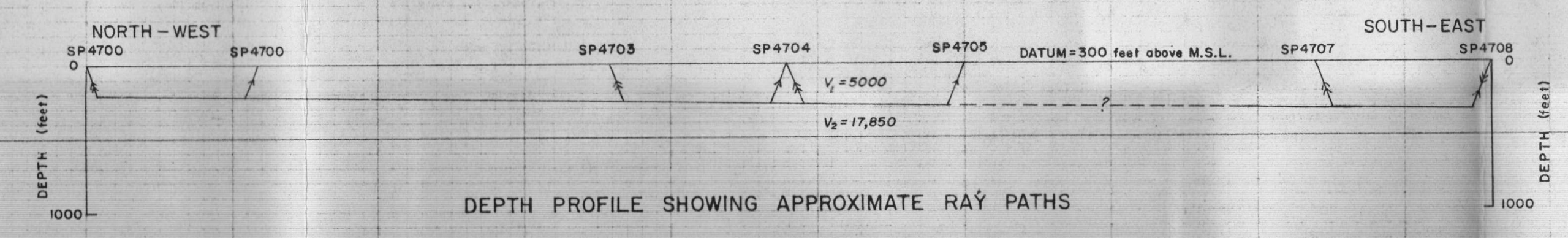
SP5007

t_o	450	432	411	397	379	366	350	329	307	293	277	262	—	229	212	194	173	155	133	114	93	73	54	32	—
W_c+E_c	30	30	30	29	29	29	29	29	29	28	28	28	28	28	28	28	28	28	28	28	28	28	28	27	27
t_c	420	402	381	368	350	337	321	300	278	265	249	234	—	201	184	166	145	127	105	86	65	45	26	5	—
	5003						5004						5005						5006						5007

SP 5010

t_o	767	754	733	719	—	688	675	655	640	619	606	589	—	543 559	530 545	510 531	494 516	477	460	439	423	405	390	372	357
W_c+E_c	27	27	27	26	26	26	26	26	26	25	25	25	25	25	25	25	25	25	25	25	25	25	25	24	24
t_c	740	727	706	693	—	662	649	629	614	594	581	564	—	518 534	505 520	485 606	469 491	452	435	414	398	380	365	348	333
	5003						5004						5005						5006						5007





DEPTH PROFILE SHOWING APPROXIMATE RAY PATHS

SP 4700

t_o	206	217	234	249	266	280	298	317	340	—	374	389	—	425	439	461	474	489	508	529	—	—	—	—	—
W_c+E_c	15	15	15	15	15	15	15	15	16	16	16	16	16	16	16	16	17	17	17	17	18	18	18	18	18
t_c	191	202	219	234	251	265	283	302	324	—	358	373	—	409	423	445	457	472	490	512	—	—	—	—	—
	4701						4702						4703						4704						4705

SP 4700

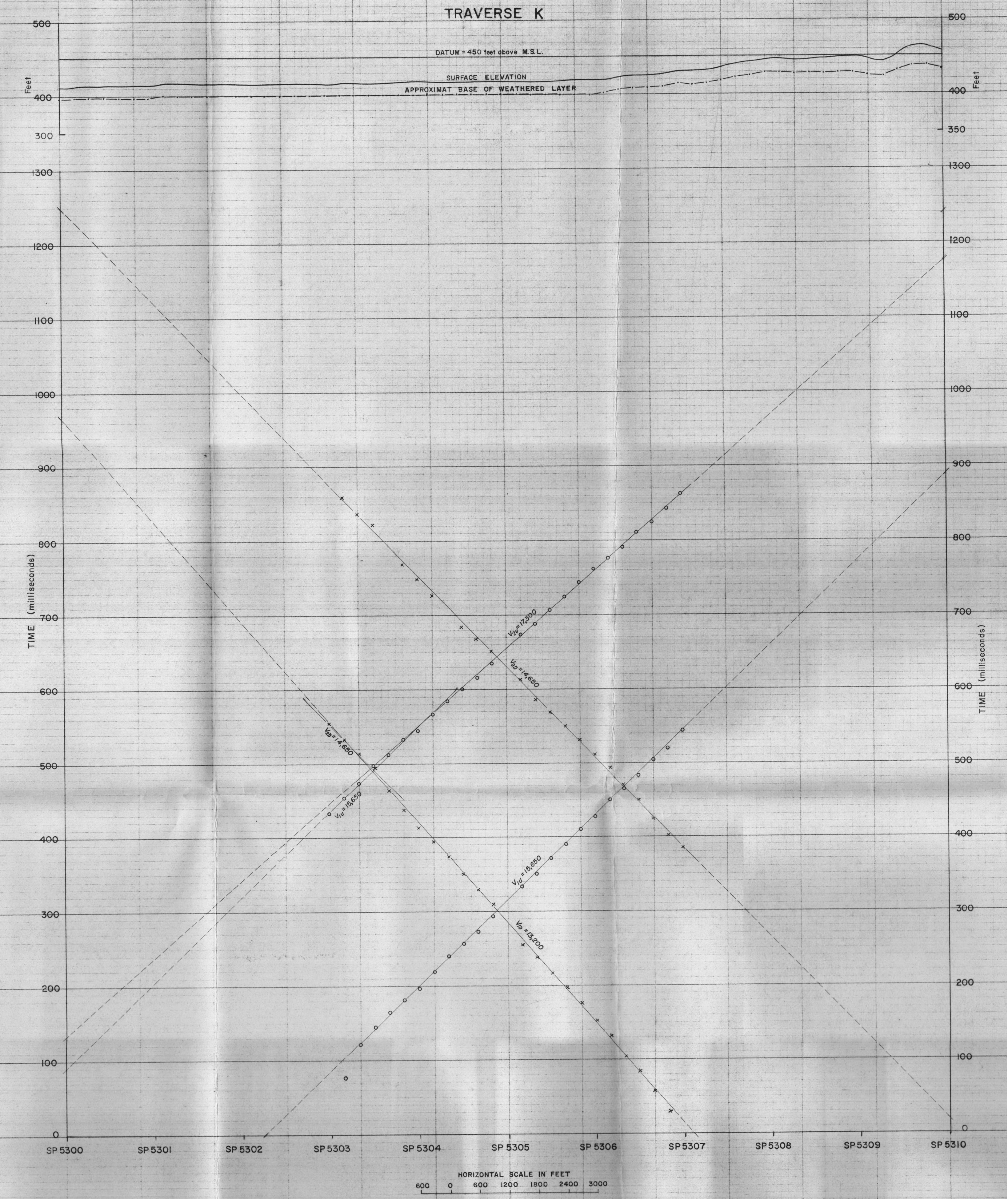
t_o	506	529	541	558	578 602	596 617	606 632	651	661	684	713	743	—	773	789	804	821	829	848	861	878	900	916	929	947
W_c+E_c	17	17	18	18	18	18	18	19	19	20	20	21	22	22	23	23	22	22	23	23	25	26	28	28	26
t_c	489	512	523	540	560 584	576 599	588 614	632	642	664	693	722	—	751	766	781	799	807	825	838	853	874	888	901	921
	4704						4705						4706						4707						4708

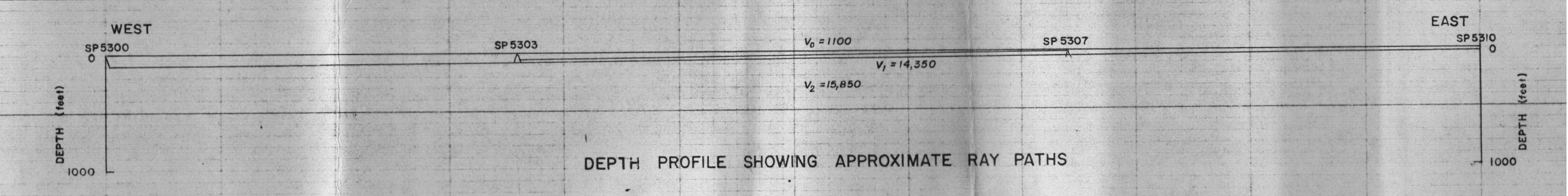
SP 4708

t_o	651	635	617	602	588	574	562	552	538	517	511	491	—	458	447	432	408	386	367	346	324	299	283	269	256
W_c+E_c	28	28	28	28	29	29	29	29	30	30	30	30	30	31	31	32	32	33	34	34	35	35	34	34	35
t_c	623	607	589	574	559	545	533	523	508	487	481	461	—	427	416	400	376	353	333	312	289	264	249	235	221
	4703						4704						4705						4706						4707

SP 4708

t_o	940	928	909	894	876	860	846	832	816	796	779	762	—	731	715	707	685	665	644	632	619	602	585	570	557
W_c+E_c	26	26	26	26	26	27	27	27	27	27	27	27	27	27	28	28	28	28	28	28	28	28	29	29	29
t_c	914	902	883	868	850	833	819	805	789	769	752	735	—	704	687	679	657	637	616	604	591	574	556	541	528
	4700						4701						4702						4703						4704





DEPTH PROFILE SHOWING APPROXIMATE RAY PATHS

SP5303

t_o	—	73	117	141	160	176	194	216	237	254	270	292	—	330	346	368	387	407	425	447	464	482	502	519	543
W_c+E_c	-5	-5	-5	-5	-5	-4	-4	-4	-4	-4	-4	-4	-4	-5	-5	-4	-4	-4	-4	-4	-3	-3	-3	-2	-2
t_c	—	78	122	146	165	182	198	220	241	258	274	296	—	335	351	372	391	411	429	451	467	485	505	521	545
	5303						5304						5305						5306						5307

SP 5300

t_o	428	450	470	493	509	531	542	563	582	597	613	632	—	670	684	704	721	740	758	774	789	809	823	841	862
W_c+E_c	-5	-5	-5	-5	-5	-4	-4	-4	-4	-4	-4	-4	-4	-5	-5	-4	-4	-4	-4	-4	-3	-3	-3	-2	-2
t_c	433	455	475	498	514	535	546	567	586	601	617	636	—	675	689	708	725	744	762	778	792	812	826	843	864
	5303						5304						5305						5306						5307

SP 5307

t_o	555	534	514	496	464	438	414	395	374	352	330	311	—	264	239	218	198	177	154	133	107	86	60	33	—
W_c+E_c	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	3	3	3	3	4
t_c	554	533	513	495	463	436	412	393	372	350	328	309	—	263	238	216	196	175	152	131	104	83	57	30	—
	5303						5304						5305						5306						5307

SP5310

t_o	—	861	839	824	—	772	751	731	—	687	671	655	—	615	590	573	554	535	515	497	475	454	429	406	391
W_c+E_c	2	2	2	2	2	3	3	3	3	3	3	3	3	2	2	3	3	3	3	3	4	4	4	4	5
t_c	—	859	837	822	—	769	748	728	—	684	668	652	—	613	588	570	551	532	512	494	471	450	425	402	386
	5303						5304						5305						5306						5307

TRAVERSES P, J, I, AND K

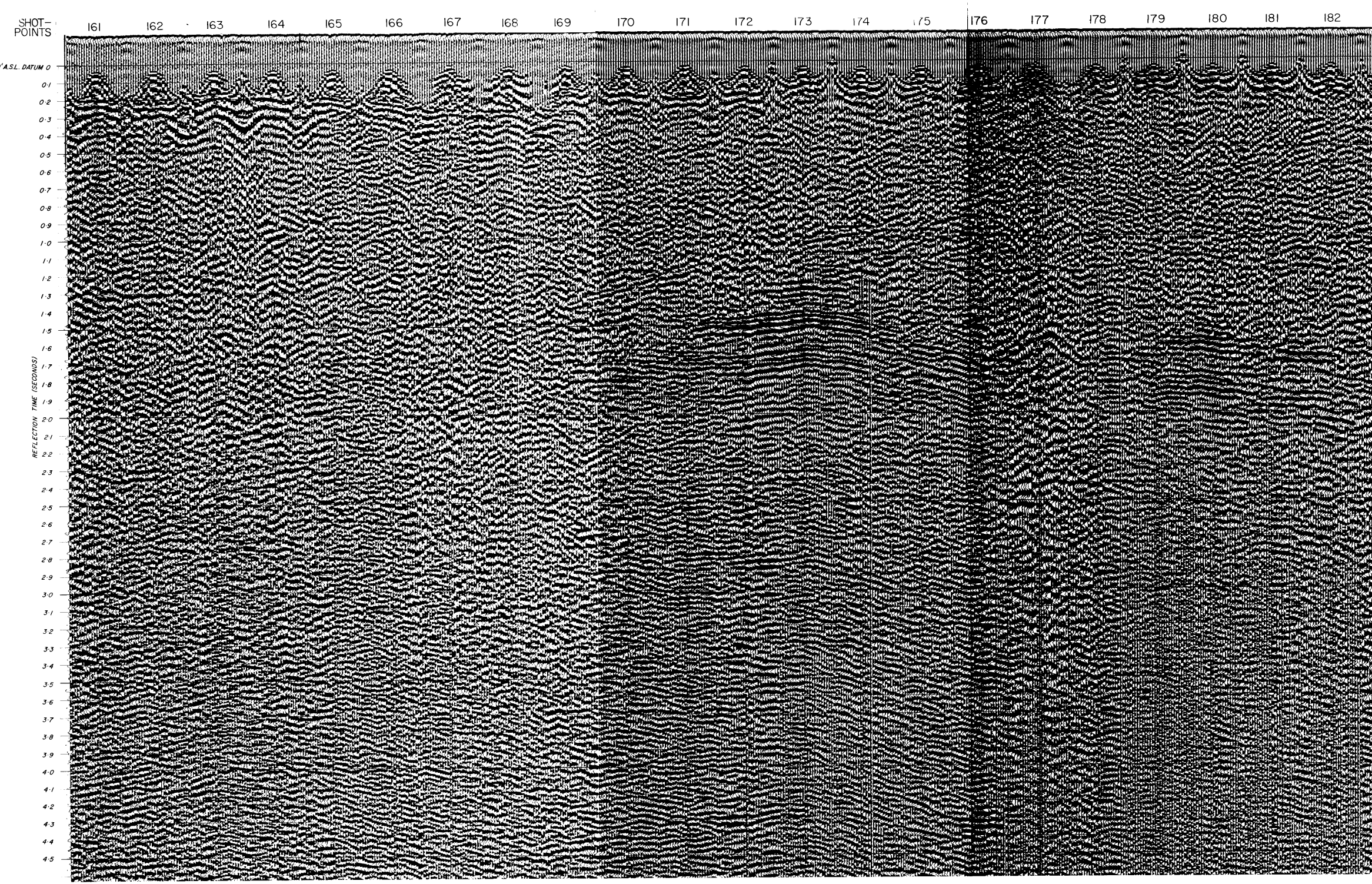
REFRACTION TIME/DISTANCE GRAPHS

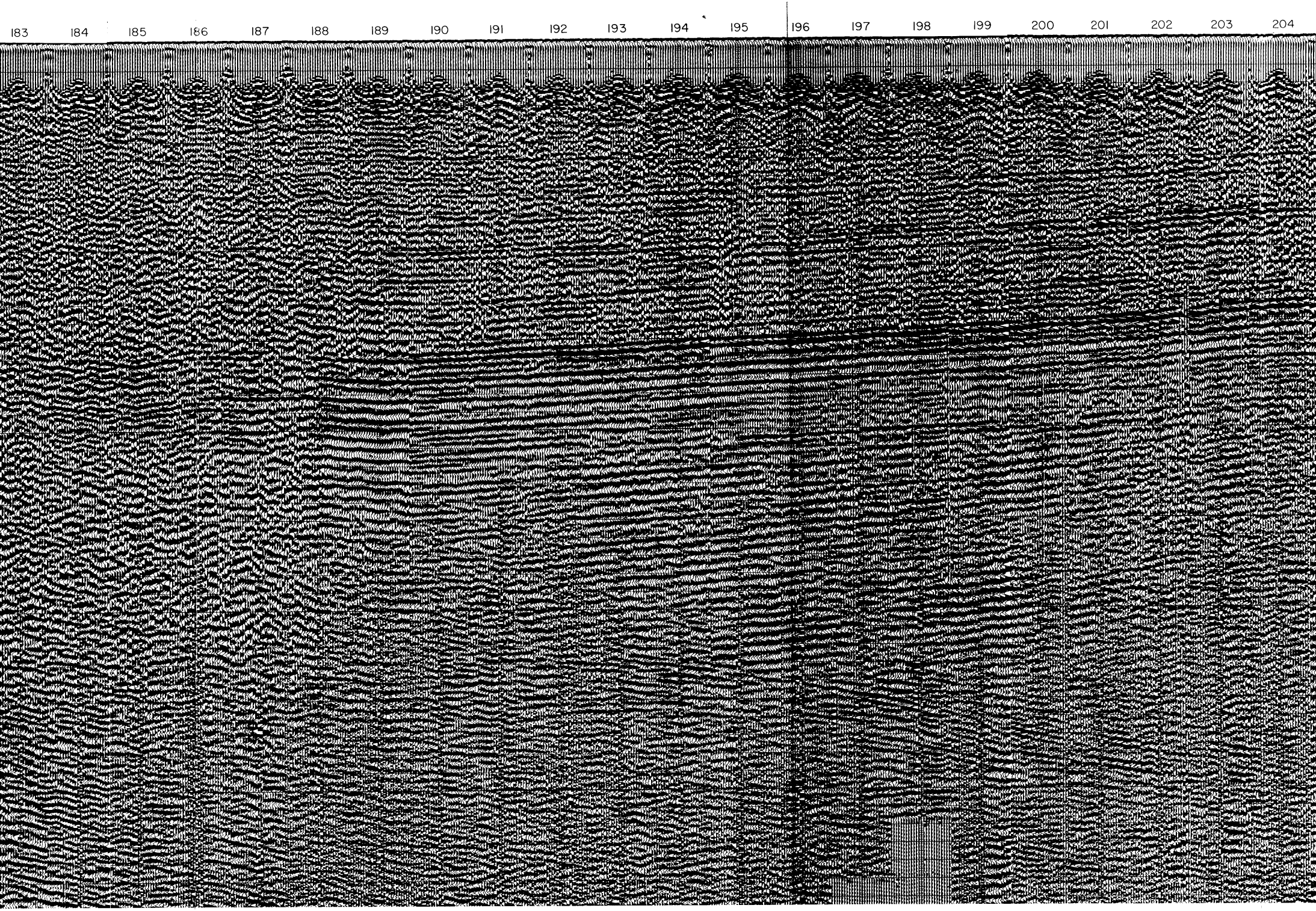
V_1 = 17,850 Seismic velocity (ft/s) in formation

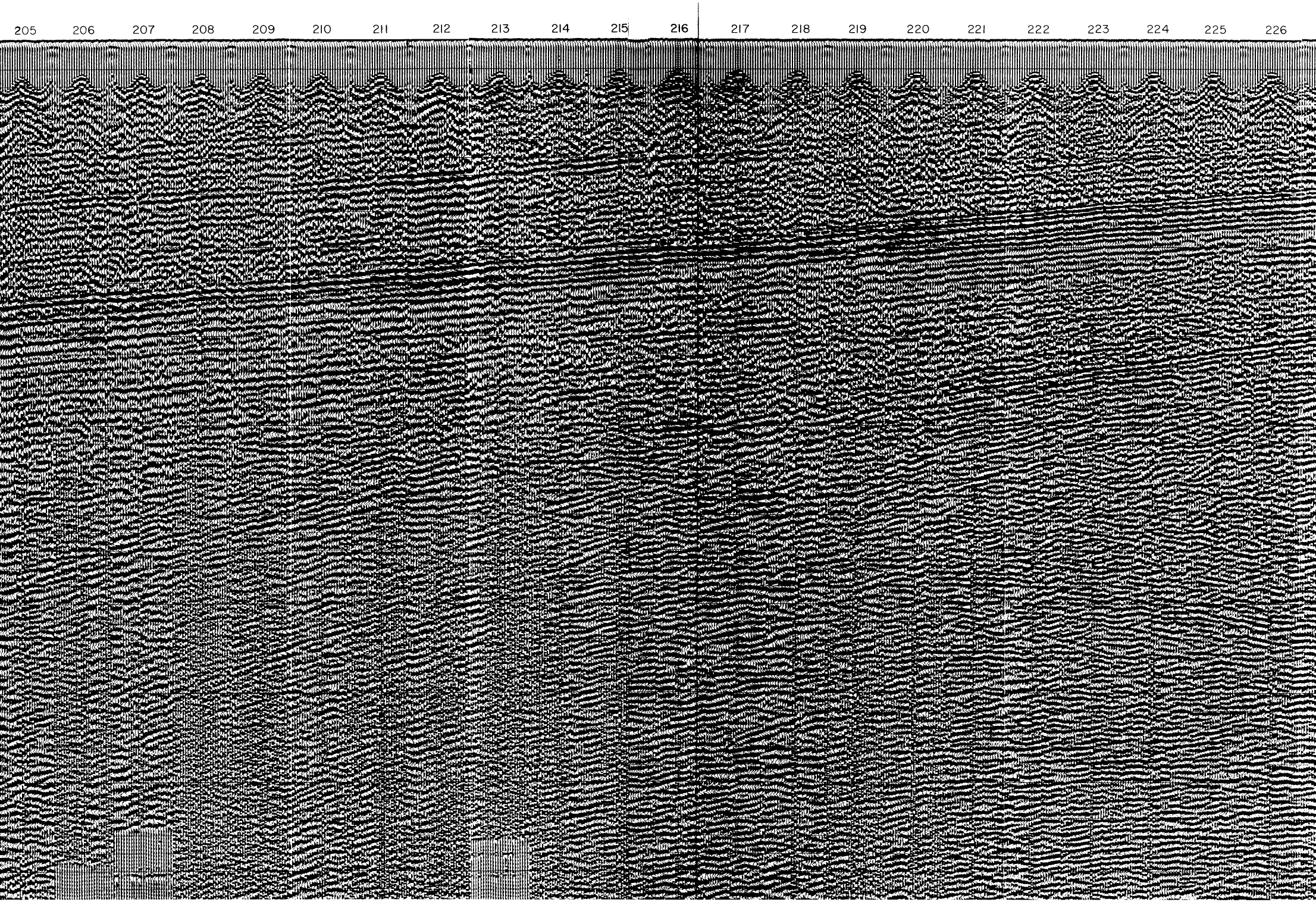
TO ACCOMPANY RECORD No. 1967/90

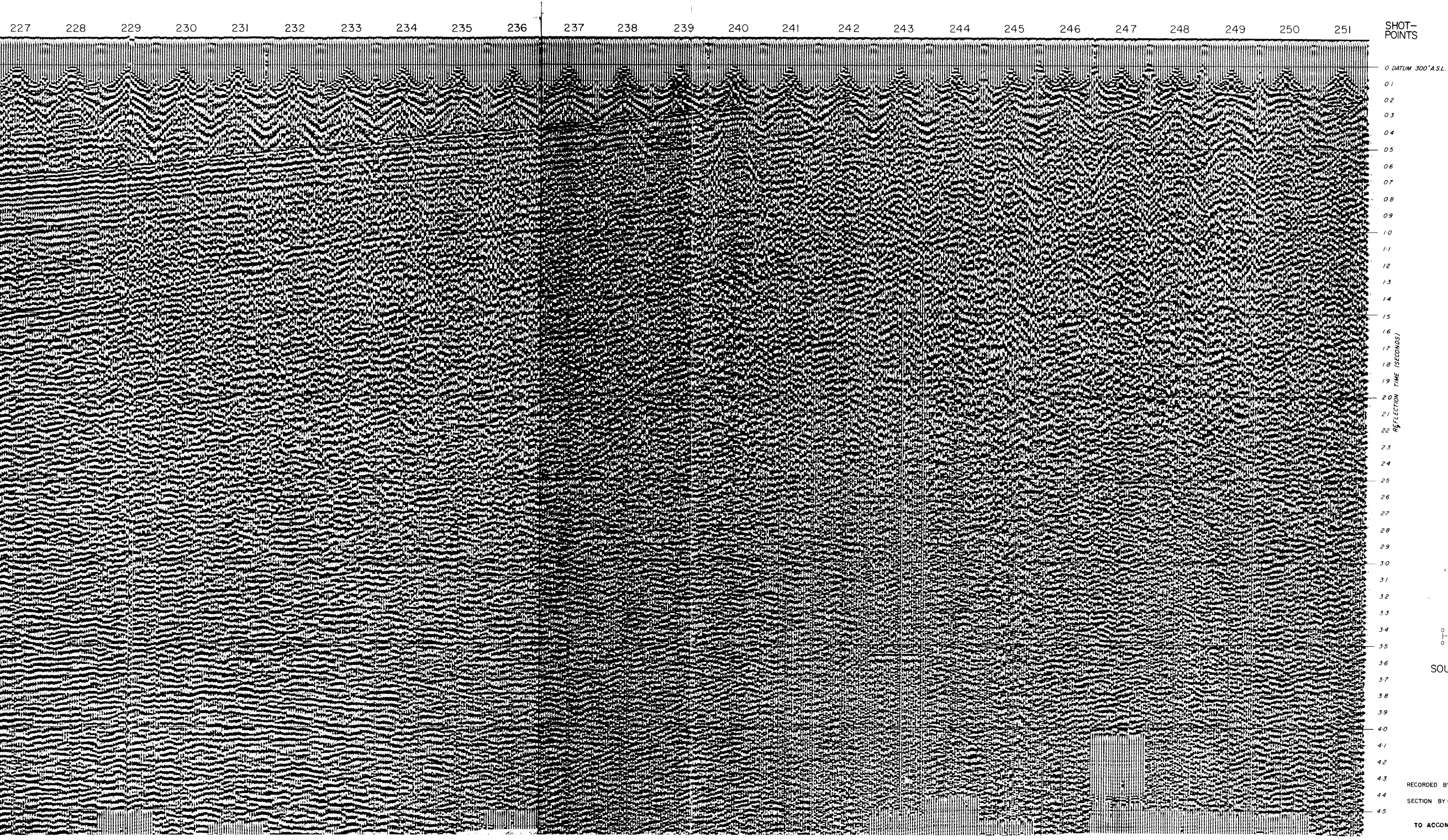
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

F54/B3-133









CORRECTED RECORD SECTION

PI

RECORDING INFORMATION

Magnetic Recorder: DS7

Amplifiers: 7000B

Filters: K18 – K160

A.G.C.: W.B.

Gain Initial: –55

Final: –10

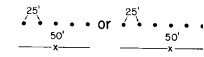
Geophones: HSJ – 14c/s

Geophone pattern:

16/trace, 20' apart in line

Station interval 150'

Shot-hole pattern:



Depth 45'

Charge 2½ to 5 lb/hole

PLAYBACK INFORMATION

Filters: 1/20 – 1/60

A.G.C.: S.S.

Gain Initial: –40

Final: –20

Trip delay: 0

Compositing: Nil

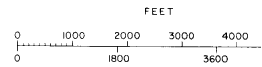
VELOCITY INFORMATION

t;Δt analysis and

Expanded Spread Velocity Shoot

Traverses E, U, W, T. H

HORIZONTAL SCALE



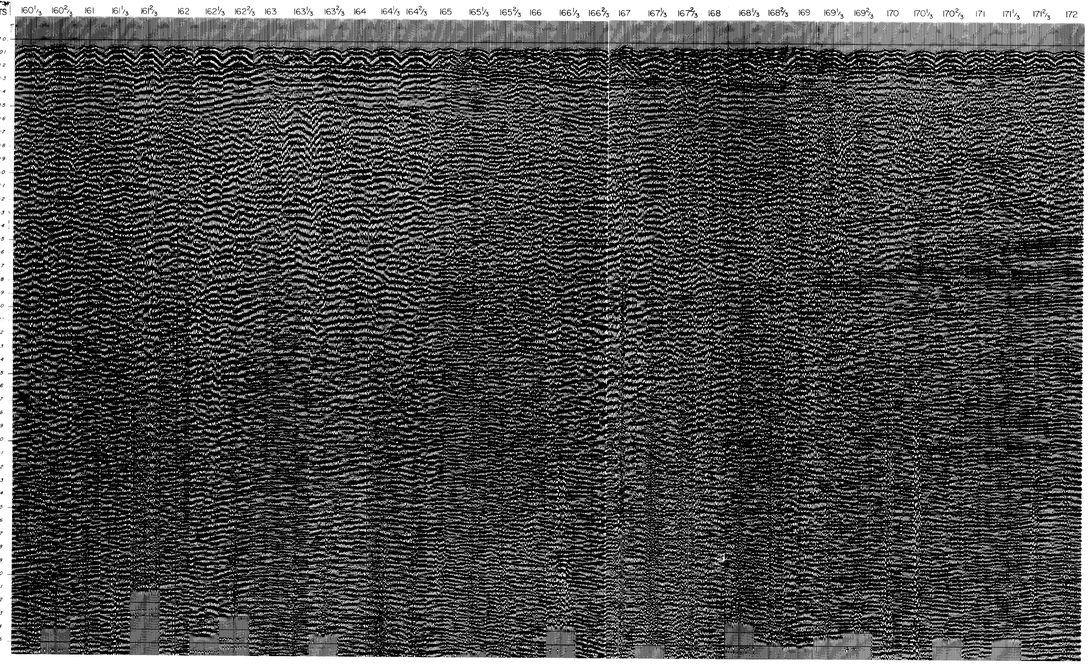
SOUTH-EASTERN GEORGINA
SEISMIC SURVEY 196

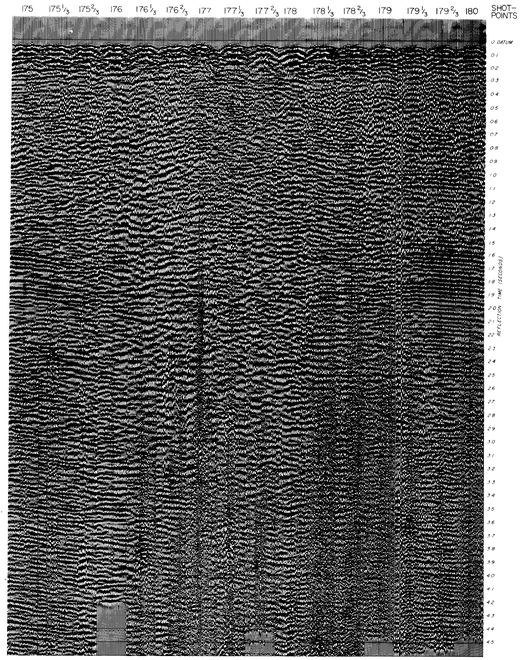
TRAVERSE F

RECORDED BY: *Seismic Party No. 1*

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

TO ACCOMPANY RECORD No 1967/90





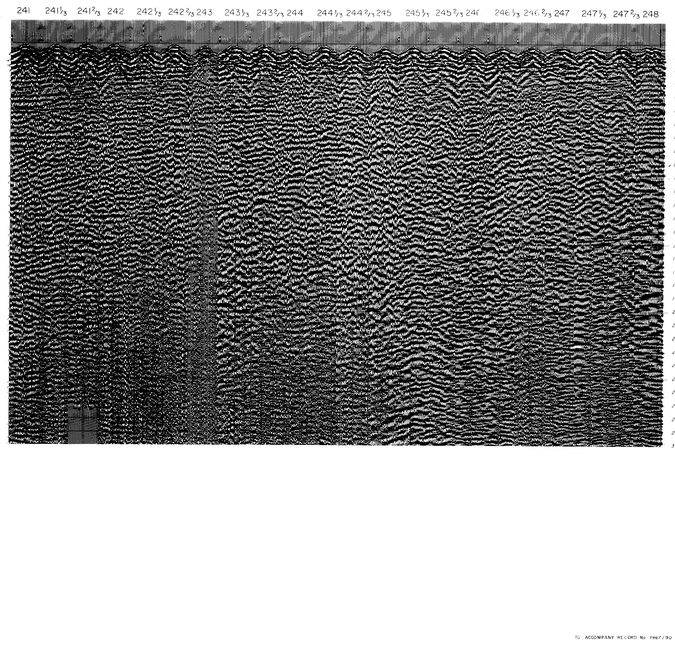


PLATE 48

CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 7000B

Filters: K18-K160

A.G.C.: W.B

Gain Initial: -55

Final: -10

Geophones: HSJ-14c/s

Geophone pattern:

16 trace, 20' apart in line

Station interval 50'

Shot-hole pattern:

Depth 45'

Charge 2½ to 5 lb/hole

PLAYBACK INFORMATION

Filters: 1/20-1/78

A.G.C.: S.S.

Gain Initial: -40

Final: -20

Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

1:1 analysis and

Expanded Spread Velocity Shoot

Traverses E,U,W,T,H

HORIZONTAL SCALE

SOUTH-EASTERN GEORGINA BASIN

SEISMIC SURVEY 1963

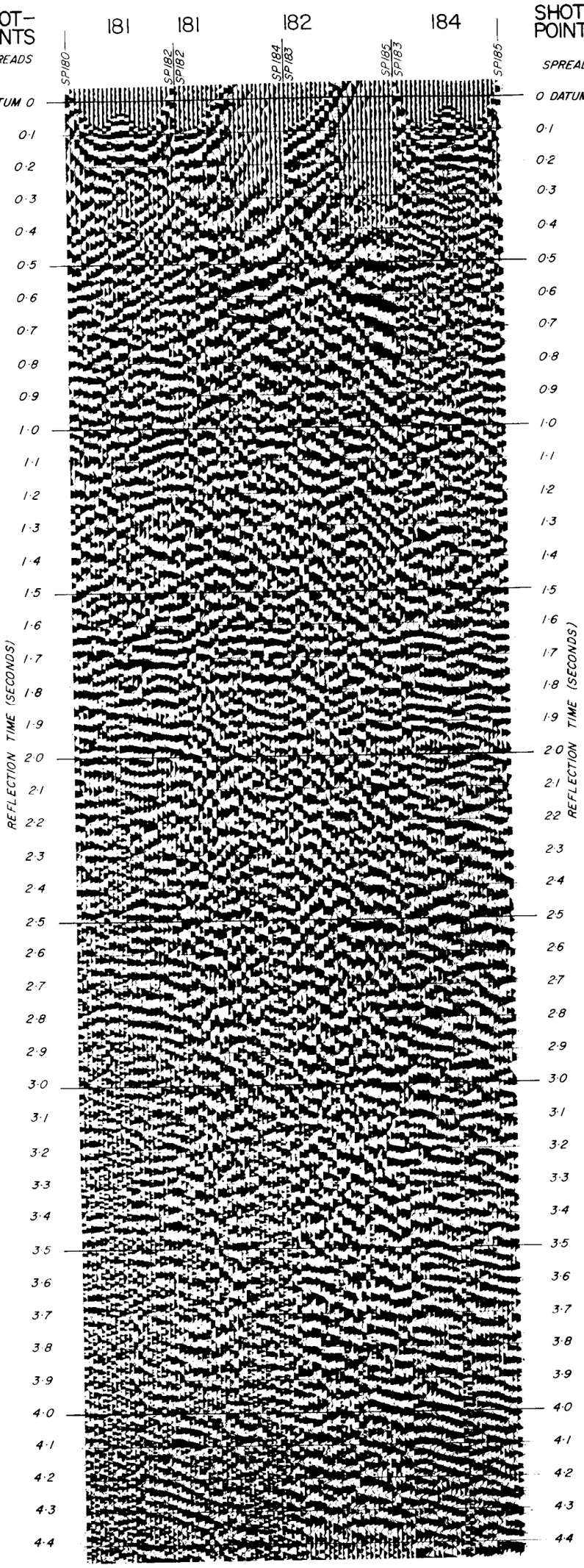
TRAVERSE F

RECORDED BY: Seismic Party No.1

SECTION BY: Bureau of Mineral Resources Playback Centre SE MS #2

TO ACCOMPANY RECORD No. 1967/90

F54/83-138



CORRECTED RECORD SECTION

PLATE 49

(COLLINEAR OFFSET)

RECORDING INFORMATION

Magnetic Recorder : DS7–7

Amplifiers : 7000B

Filters : K18 – K160

A.G.C. : W.B.

Gain Initial : –55

Final : –10

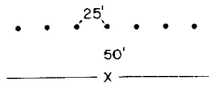
Geophones : HSJ 14c/s

Geophone pattern :

16/trace, 10' apart in line

Station interval 150'

Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 1/20 – 1/60

A.G.C. : S.S.

Gain Initial : –40

Final : –20

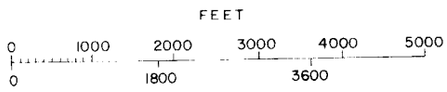
Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

t : Δ t

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1963

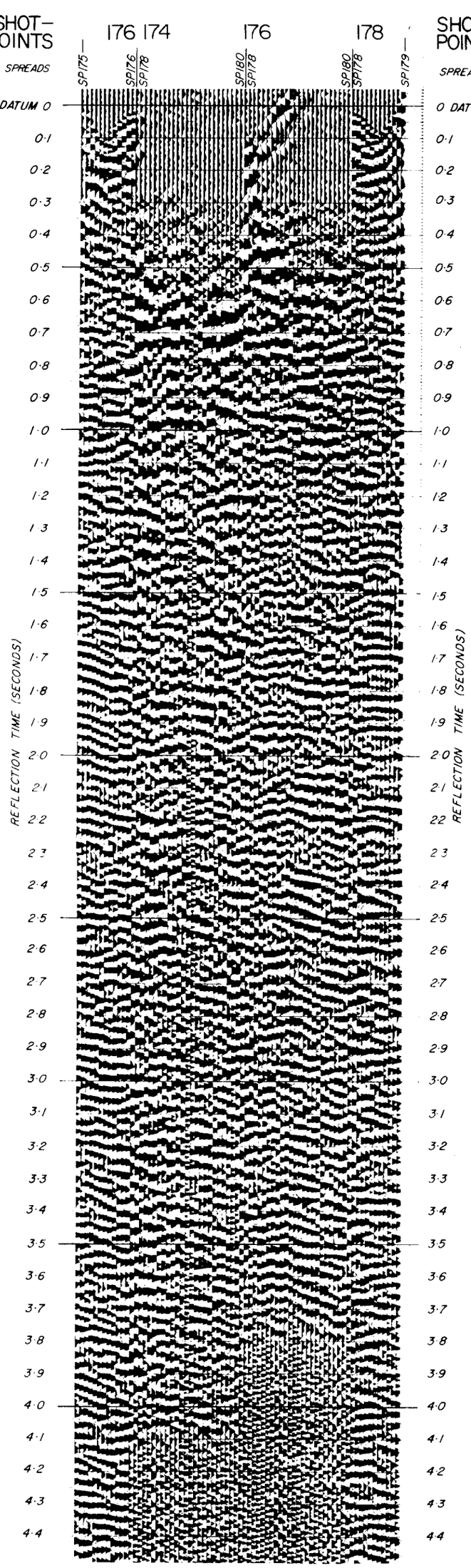
TRAVERSE F

RECORDED BY : *Seismic Party No.1*

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

TO ACCOMPANY RECORD No. 1967/90

F54/B3–145



CORRECTED RECORD SECTION

PLATE 50

(COLLINEAR OFFSET)

RECORDING INFORMATION

Magnetic Recorder : DS7–7

Amplifiers : 7000B

Filters : K18 – K160

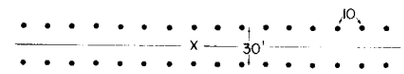
A.G.C. : W.B.

Gain Initial : –55

Final : –10

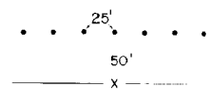
Geophones : HSJ 14c/s

Geophone pattern :



Station interval 150'

Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 1/20 – 1/60

A.G.C. : S.S.

Gain Initial : –40

Final : –20

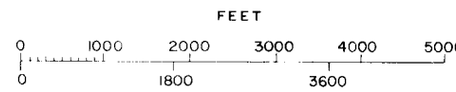
Trip delay : 0

Compositing : Nil

VELOCITY INFORMATION

t·Δt

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1963

TRAVERSE F

RECORDED BY : *Seismic Party No.1*

SECTION BY : *Bureau of Mineral Resources*

Playback Centre SIE MS 42

TO ACCOMPANY RECORD No. 1967/90

F54/B3–144

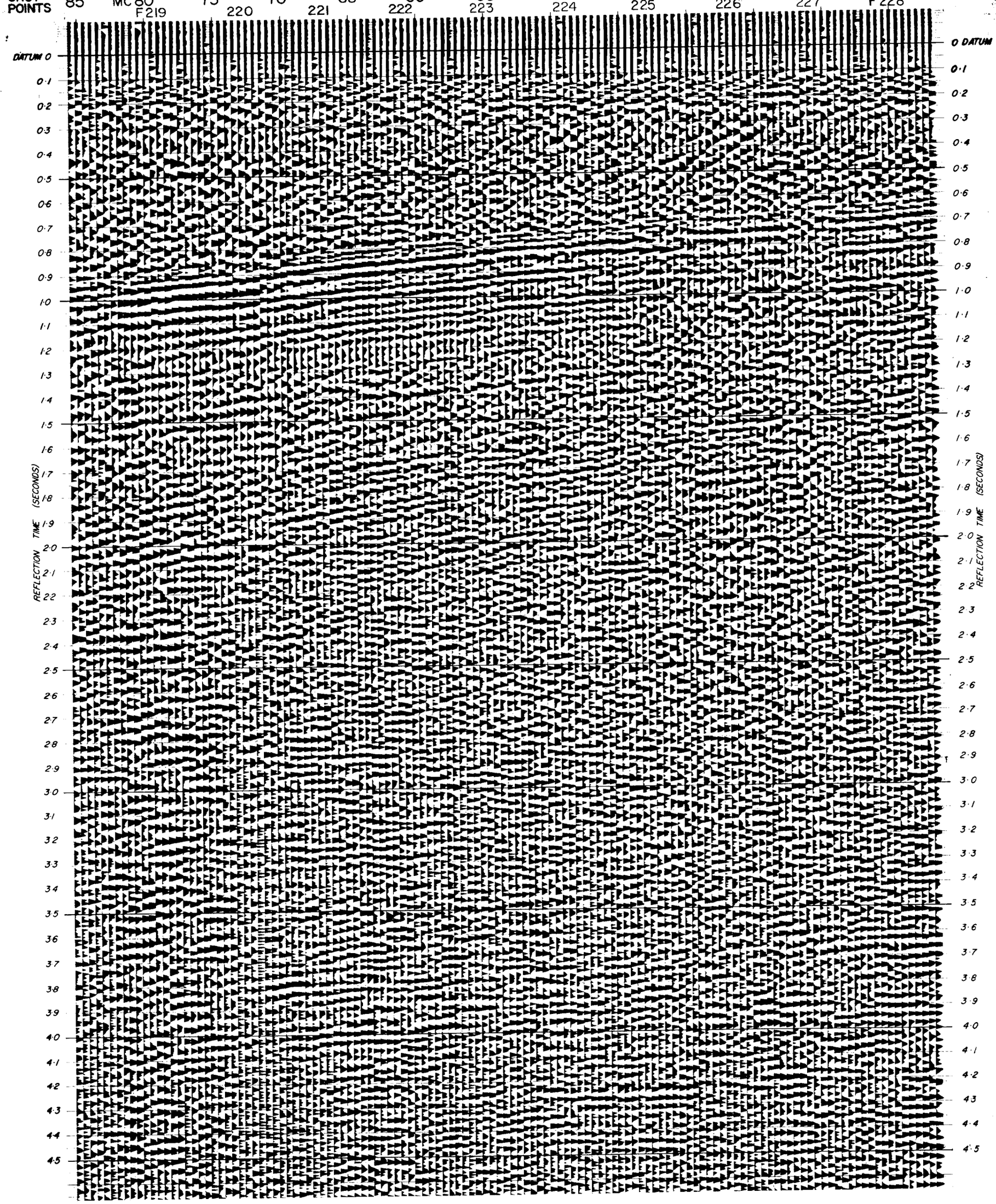


PLATE 51

CORRECTED RECORD SECTION

(3 FOLD - NEAREST 12 TRACES)

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 7000B

Filters: K18-K92

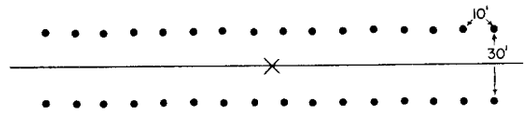
A.G.C.: WB

Gain Initial: -60 (1 to 12), -50 (13 to 24)

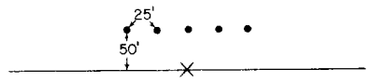
Final: -10 to -30 (Varied)

Geophones: HS-J 14 c/s

Geophone pattern:



Shot-hole pattern:



PLAYBACK INFORMATION

Filters: 1/20 1/78

A.G.C.: Super Slow

Gain Initial: -50

Final: -20

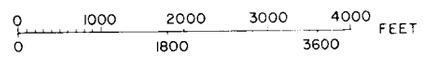
Trip delay: 0·1 s

Compositing: 3 Fold Stack - Nearest 12 Traces

VELOCITY INFORMATION

t: Δt., Velocity Spreads, Traverses H and T

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1964

TRAVERSE F

MULTIPLE COVERAGE

RECORDED BY: *Seismic Party No.1*

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

F54/83-84

TO ACCOMPANY RECORD No. 1967/90

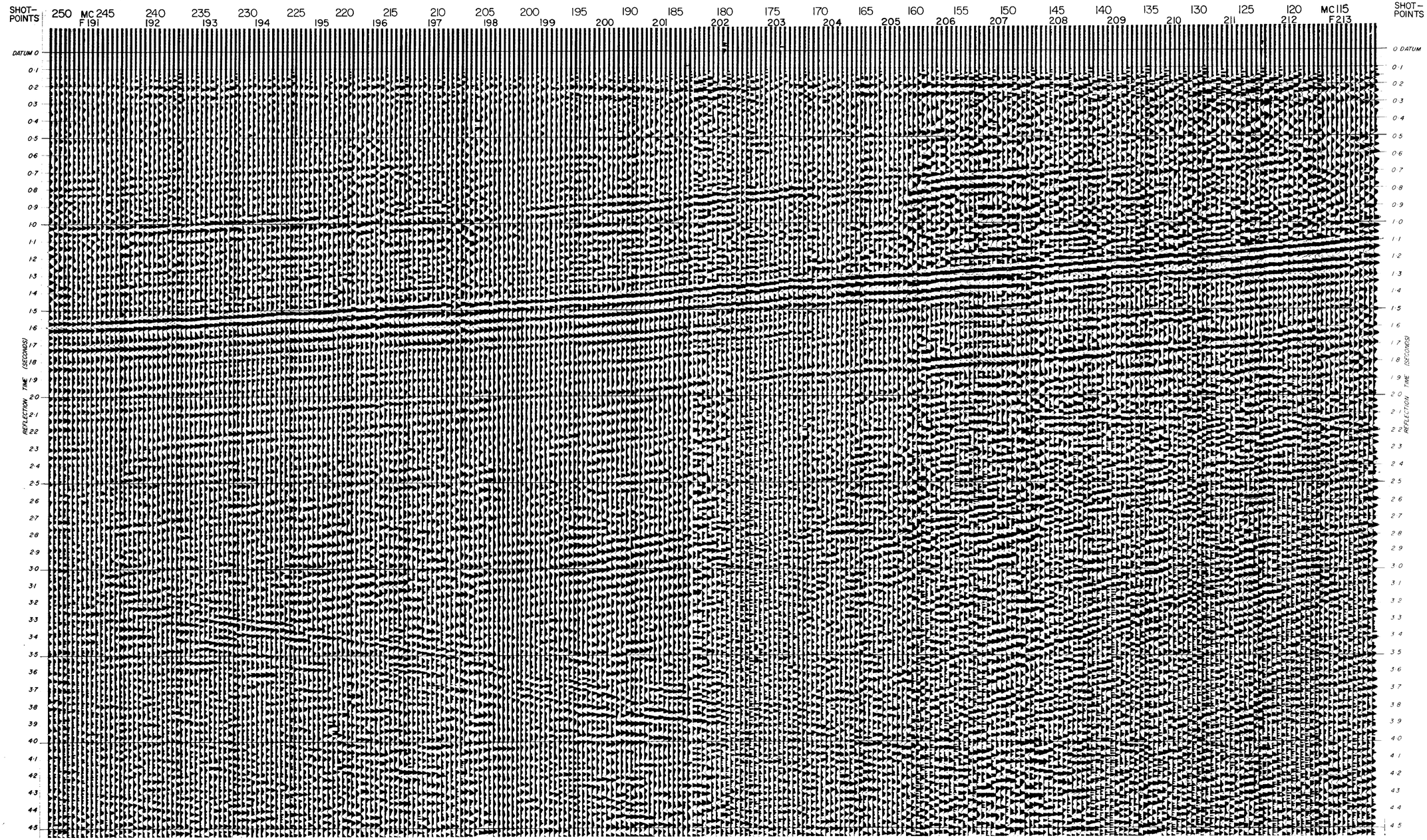


PLATE 52

CORRECTED RECORD SECTION
(3 FOLD – NEAREST 12 TRACES)

RECORDING INFORMATION

Magnetic Recorder DS7 – 7

Amplifiers : 7000 B

Filters : K18 – K92

A.G.C. : W.B.

Gain Initial : – 60 (1 to 12), – 50 (13 to 24)

Final : – 10 to – 30 (Variable)

Geophones HS-J 14 c/s

Geophone pattern :

20'

Shot-hole pattern

25' 25'

50' 50'

OR

PLAYBACK INFORMATION

Filters : 1/20 – 1/78

A.G.C. : S.S.

Gain Initial : – 40

Final : – 20

Trip delay : ~ 2 s.

Compositing : 3 FOLD STACK – nearest 12 traces

VELOCITY INFORMATION

t: Δt

VELOCITY SPREADS, TRAVERSES E, U & W

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET

0 1800 3600

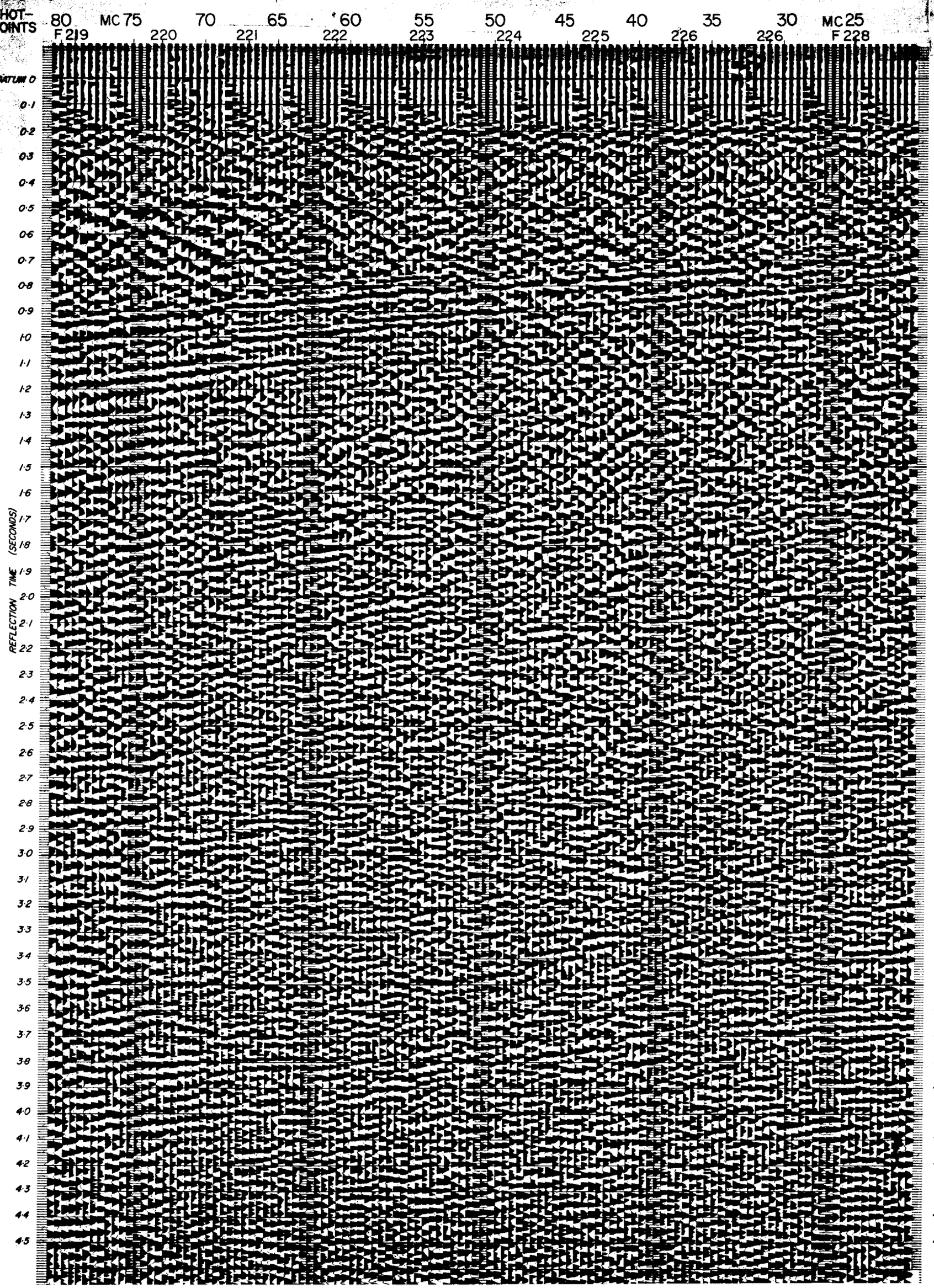
SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE F
MULTIPLE COVERAGE

RECORDED BY *Seismic Party No 1*

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SYE MS 42 F54/B3–[illegible]

TO ACCOMPANY RECORD No.1967/90



SHOT-POINTS
0 DATUM
0·1 0·2 0·3 0·4 0·5 0·6 0·7 0·8 0·9 1·0 1·1 1·2 1·3 1·4 1·5 1·6 1·7 1·8 1·9 2·0 2·1 2·2 2·3 2·4 2·5 2·6 2·7 2·8 2·9 3·0 3·1 3·2 3·3 3·4 3·5 3·6 3·7 3·8 3·9 4·0 4·1 4·2 4·3 4·4 4·5
REFLECTION TIME (SECONDS)

CORRECTED RECORD SECTION

(3 FOLD - 24 TRACES)

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 7000B

Filters: K18-K92

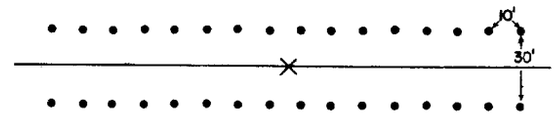
A.G.C.: WB

Gain Initial: -60(1 to 12), -50(13 to 24)

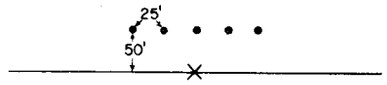
Final: -10 to -30 (Varied)

Geophones: HS-J 14 c/s

Geophone pattern:



Shot-hole pattern:



PLAYBACK INFORMATION

Filters: 1/20 1/78

A.G.C.: Super Slow

Gain Initial: -20

Final: -10

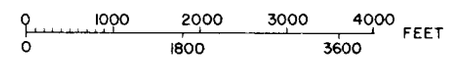
Trip delay: 0·2 s

Compositing: 3 Fold Stack - 24 Traces

VELOCITY INFORMATION

t: Δt., Velocity Spreads, Traverses H and T

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE F
MULTIPLE COVERAGE

RECORDED BY: *Seismic Party No. 1*

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

F54/B3-81

TO ACCOMPANY RECORD No. 1967/90

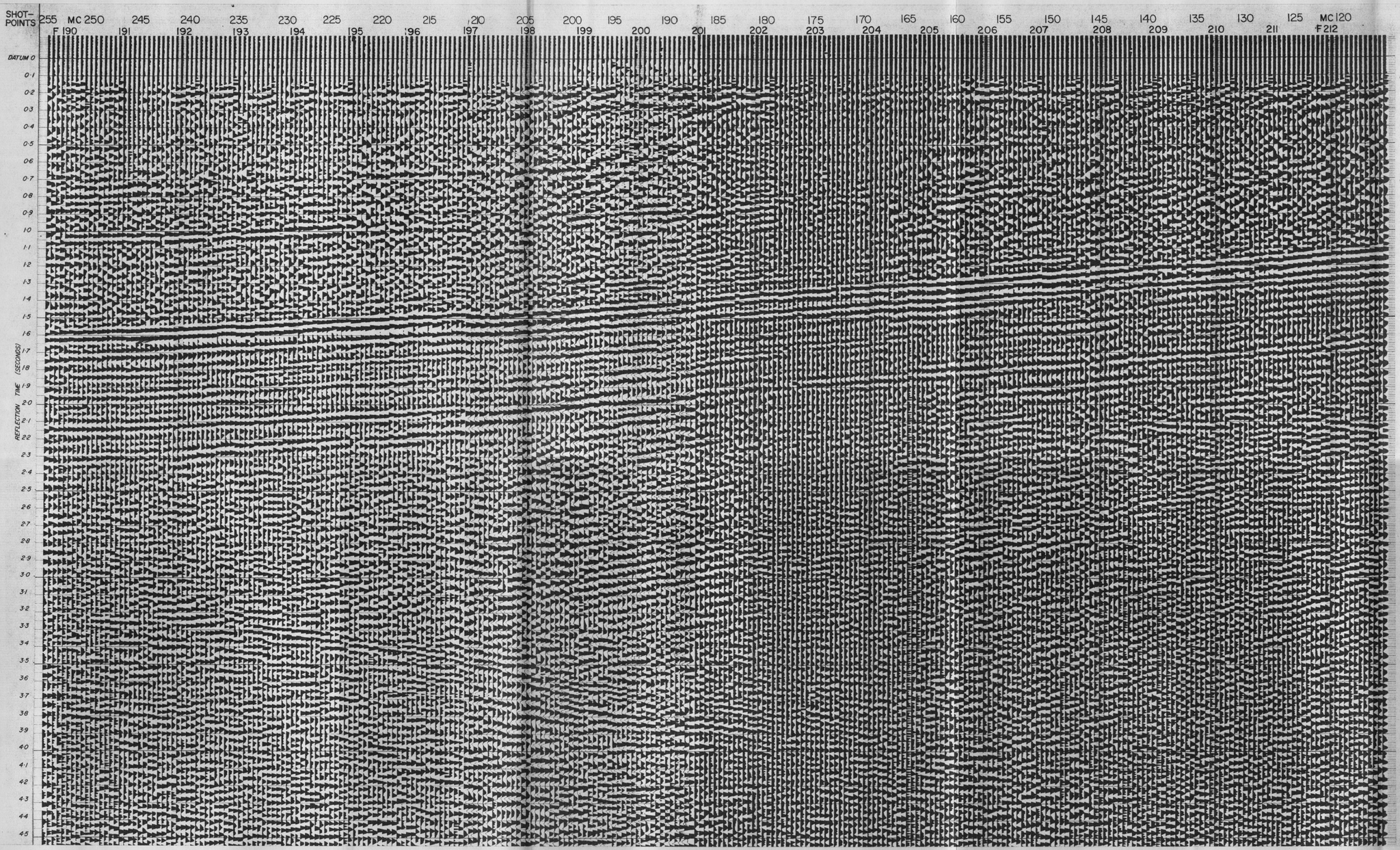


PLATE 54

CORRECTED RECORD SECTION (3 FOLD - 24 TRACES)

RECORDING INFORMATION

Magnetic Recorder DS7 - 7

Amplifiers : 7000 B

Filters : K18 - K92

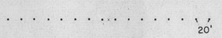
A.G.C. : W.B.

Gain Initial : - 60 (1 to 12), - 50 (13 to 24)

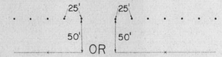
Final : - 10 to - 30 (Variable)

Geophones : HS-J 14 c/s

Geophone pattern :



Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 1/20 - 1/78

A.G.C. : S.S.

Gain Initial : - 40

Final : - 20

Trip delay : 0·2 s

Compositing : 3 FOLD STACK
24 traces

VELOCITY INFORMATION

t: Δt

VELOCITY SPREADS, TRAVERSES E,U & W

HORIZONTAL SCALE

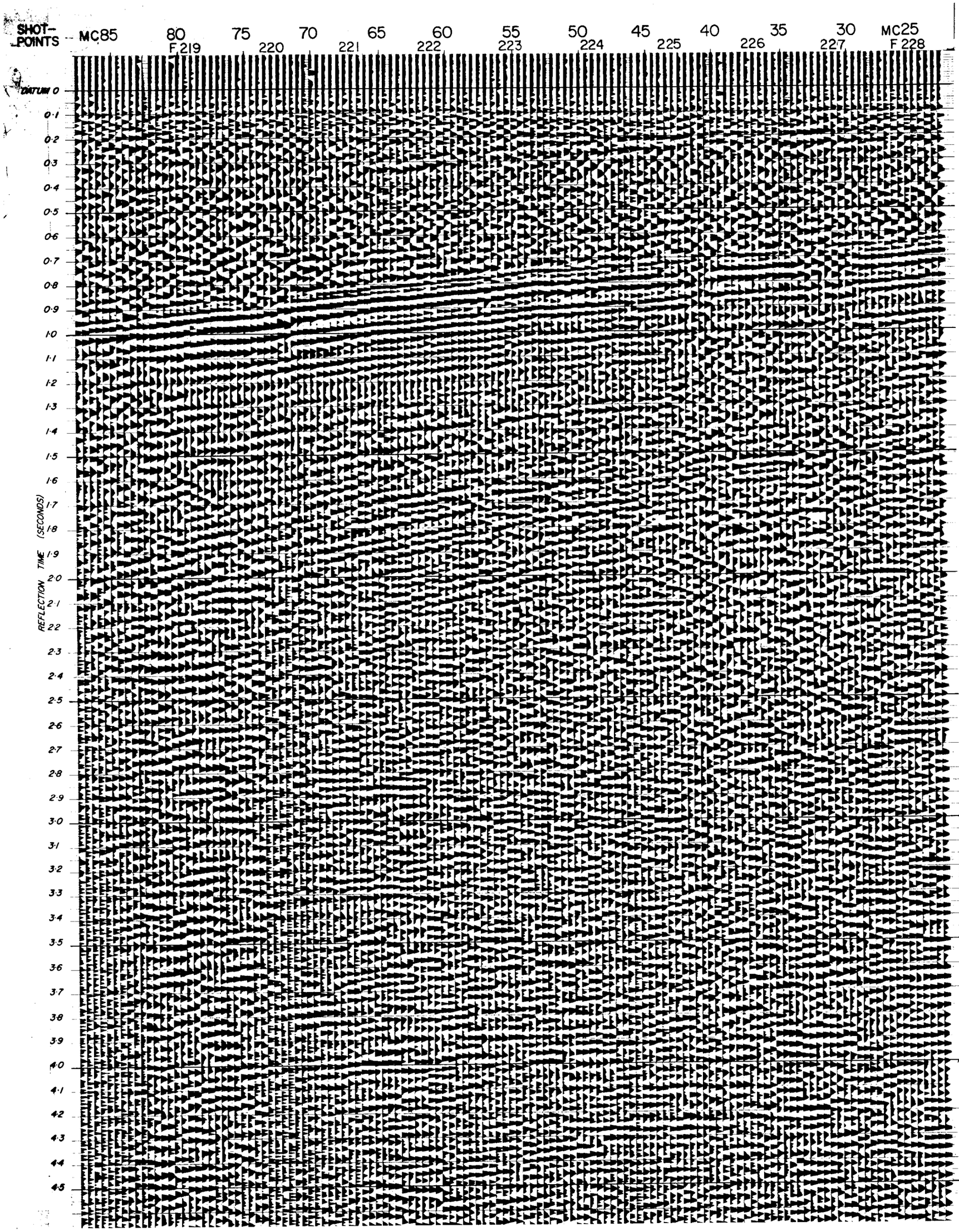
SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE F
MULTIPLE COVERAGE

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F54/83-98

TO ACCOMPANY RECORD No. 1967/90



SHOT-POINTS
0 DATUM
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
1·1
1·2
1·3
1·4
1·5
1·6
1·7
1·8
1·9
2·0
2·1
2·2
2·3
2·4
2·5
2·6
2·7
2·8
2·9
3·0
3·1
3·2
3·3
3·4
3·5
3·6
3·7
3·8
3·9
4·0
4·1
4·2
4·3
4·4
4·5
REFLECTION TIME (SECONDS)

PLATE 55

CORRECTED RECORD SECTION

(6 FOLD - NEAREST 12 TRACES)

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 7000B

Filters: K18-K92

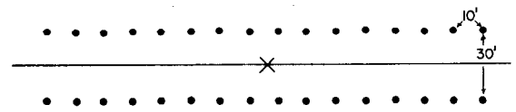
A.G.C.: WB

Gain Initial: -60 (1 to 12), -50 (13 to 24)

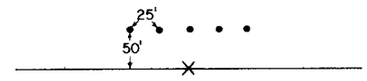
Final: -10 to -30 (Varied)

Geophones: HS-J 14 c/s

Geophone pattern:



Shot-hole pattern:



PLAYBACK INFORMATION

Filters: 1/20 1/78

A.G.C.: Super Slow

Gain Initial: -40

Final: -20

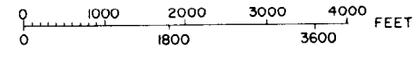
Trip delay: 0·1 s

Compositing: 6 Fold Stack - Nearest 12 Traces

VELOCITY INFORMATION

t: Δt., Velocity Spreads, Traverses H and T

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE F
MULTIPLE COVERAGE

RECORDED BY: *Seismic Party No.1*

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

F54/B3-85

TO ACCOMPANY RECORD No. 1967/90

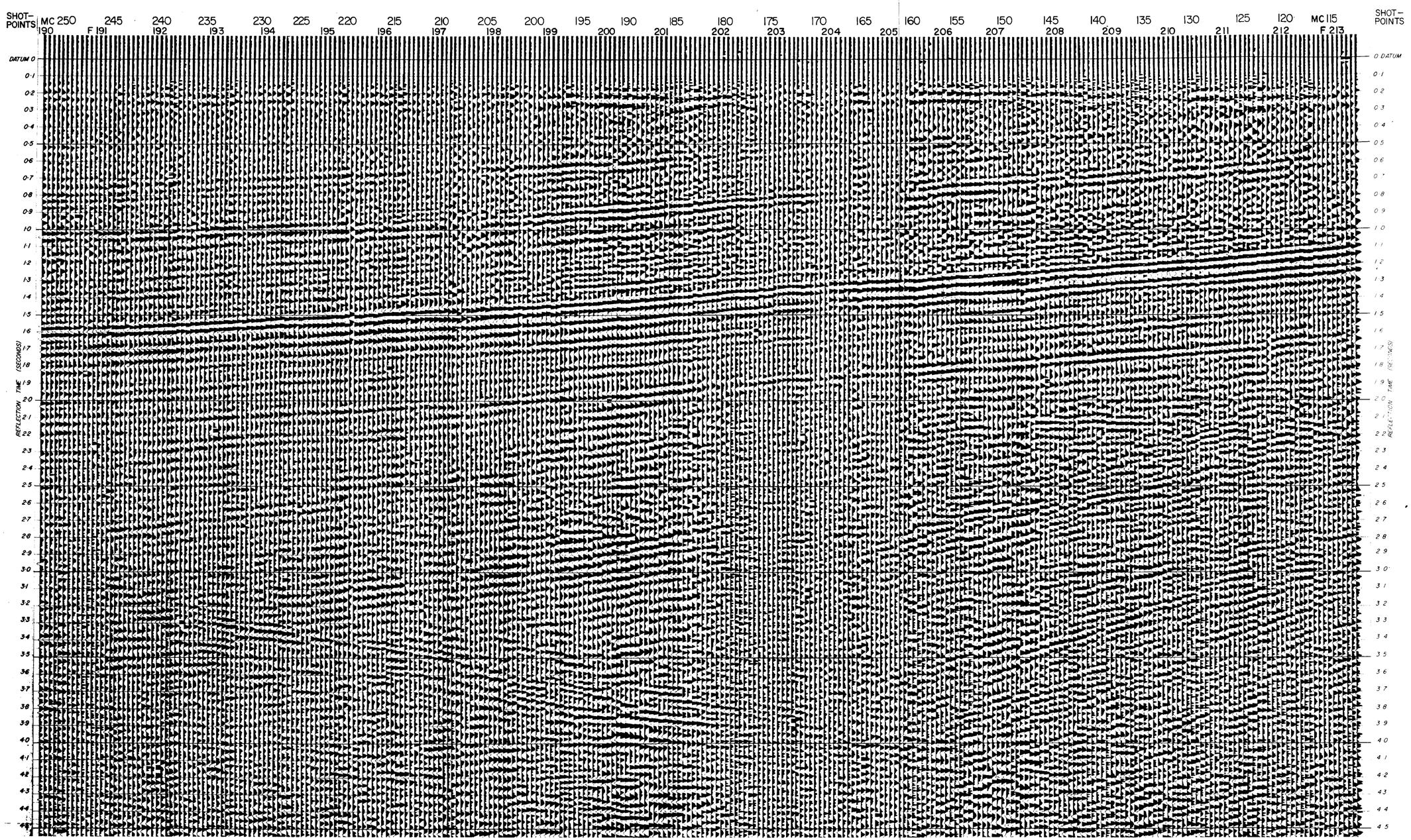


PLATE 56

CORRECTED RECORD SECTION
(6 FOLD – NEAREST 12 TRACES)

RECORDING INFORMATION

Magnetic Recorder DS7 – 7

Amplifiers : 7000 B

Filters : K18 – K92

A.G.C. : W.B.

Gain Initial : – 60 (1 to 12), – 50 (13 to 24)

Final : – 10 to – 30 (Variable)

Geophones : HS-J 14 c/s

Geophone pattern :

20'

Shot-hole pattern :

25' 25'

50' 50'

OR

PLAYBACK INFORMATION

Filters : 1/20 – 1/78

A.G.C. : S.S.

Gain Initial : – 40

Final : – 20

Trip delay : 0·1s

Compositing : 6 FOLD STACK nearest 12 traces

VELOCITY INFORMATION

t: Δt

VELOCITY SPREADS, TRAVERSES E,U&W

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET

0 1800 3600

SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

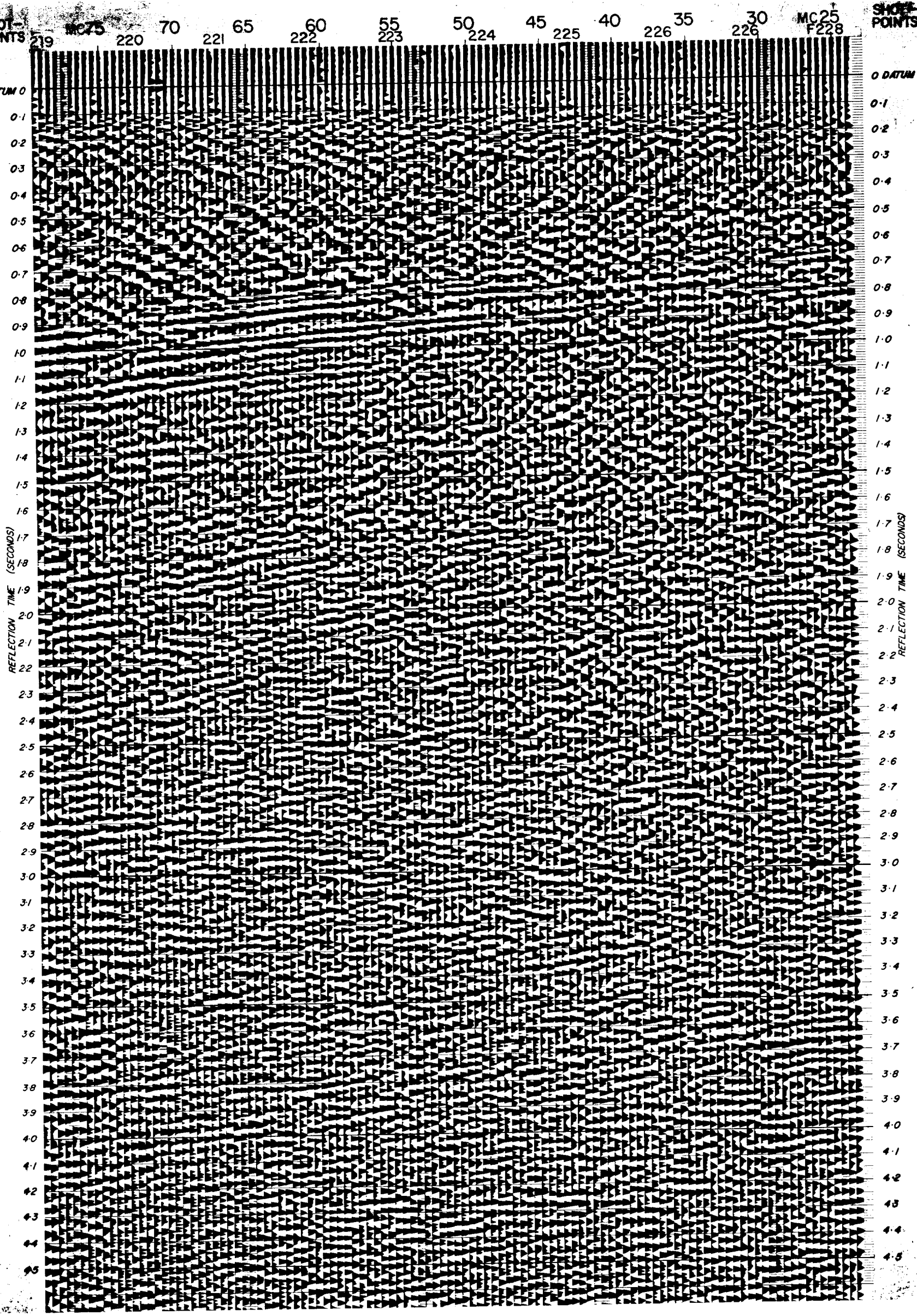
TRAVERSE F
MULTIPLE COVERAGE

RECORDED BY *Seismic Party No 1*

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

F54/B3-97

TO ACCOMPANY RECORD No 1967/90



SHOT-POINTS
0 DATUM
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
1·1
1·2
1·3
1·4
1·5
1·6
1·7
1·8
1·9
2·0
2·1
2·2
2·3
2·4
2·5
2·6
2·7
2·8
2·9
3·0
3·1
3·2
3·3
3·4
3·5
3·6
3·7
3·8
3·9
4·0
4·1
4·2
4·3
4·4
4·5
REFLECTION TIME (SECONDS)

PLATE 57

CORRECTED RECORD SECTION

(6 FOLD – 24 TRACES)

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 7000B

Filters: K18-K92

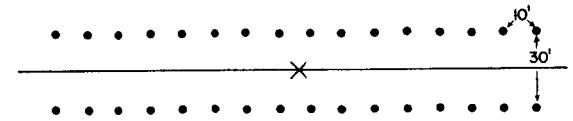
A.G.C.: WB

Gain Initial: -60(1 to 12), -50(13 to 24)

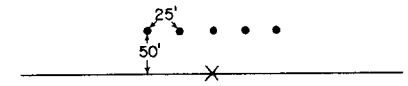
Final: -10 to -30 (Varied)

Geophones: HS-J 14 c/s

Geophone pattern:



Shot-hole pattern:



PLAYBACK INFORMATION

Filters: 1/20 1/78

A.G.C.: Super Slow

Gain Initial: -40

Final: -10

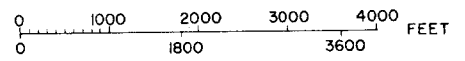
Trip delay: 0·2 s

Compositing: 6 Fold Stack – 24 Traces

VELOCITY INFORMATION

t: Δt., Velocity Spreads, Traverses H and T

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE F

MULTIPLE COVERAGE

RECORDED BY: *Seismic Party No.1*

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

F54/B3-82

TO ACCOMPANY RECORD No. 1967/90

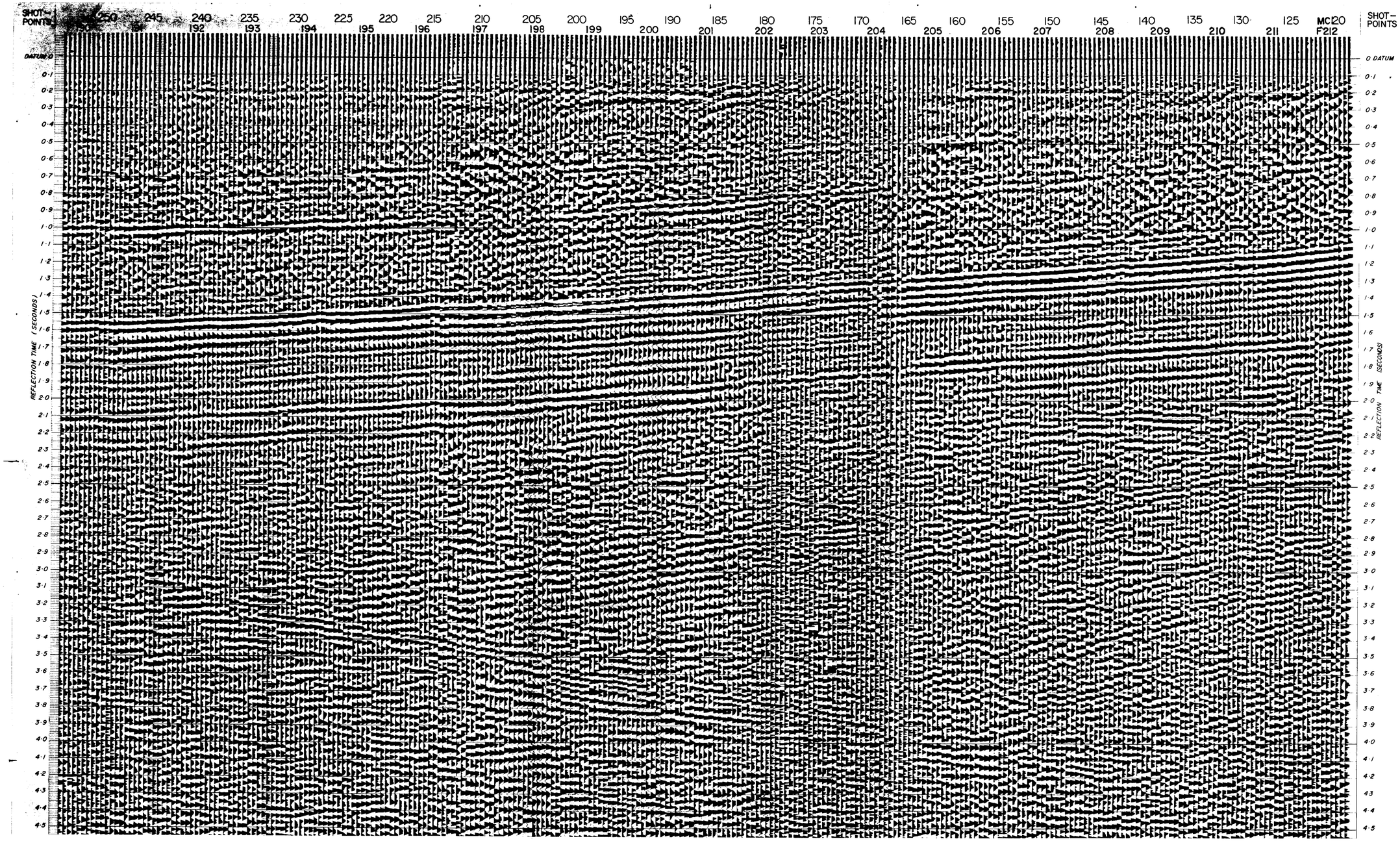


PLATE 58

CORRECTED RECORD SECTION
(6 FOLD – 24 TRACES)

RECORDING INFORMATION

Magnetic Recorder DS7 – 7

Amplifiers : 7000 B

Filters : K18 – K92

A.G.C. : W.B.

Gain Initial : – 60 (1 to 12), – 50 (13 to 24)

Final : – 10 to – 30 (Variable)

Geophones : HS-J 14 c/s

Geophone pattern :

20'

Shot-hole pattern :

25' 25'
50' 50'
OR

PLAYBACK INFORMATION

Filters : 1/20 – 1/78

A.G.C. : S.S.

Gain Initial : – 40

Final : – 10

Trip delay : 0·2 s

Compositing : 6 FOLD STACK
24 traces

VELOCITY INFORMATION

t: Δt

VELOCITY SPREADS, TRAVERSES E, U & W

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1800 3600

SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE F
MULTIPLE COVERAGE

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F54/83-99

TO ACCOMPANY RECORD No. 1967/90

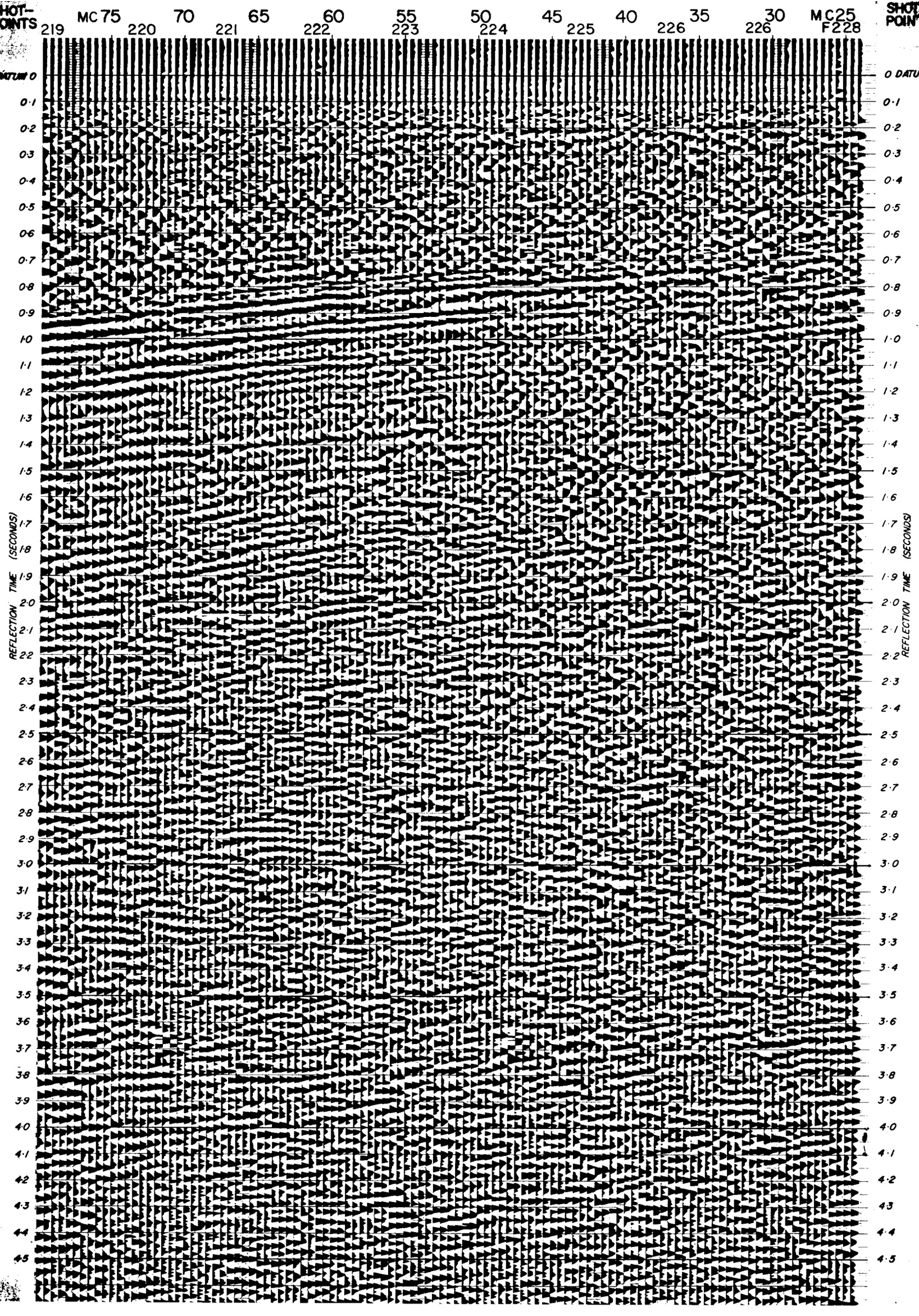


PLATE 59

CORRECTED RECORD SECTION

(12 FOLD - 24 TRACES)

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 7000B

Filters: K18-K92

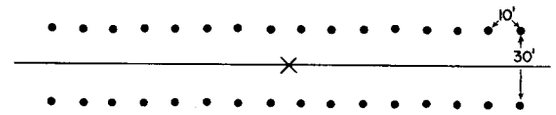
A.G.C.: WB

Gain Initial: -60(1 to 12), -50(13 to 24)

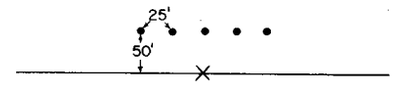
Final: -10 to -30 (Varied)

Geophones: HS-J 14 c/s

Geophone pattern:



Shot-hole pattern:



PLAYBACK INFORMATION

Filters: 1/20 1/78

A.G.C.: Super Slow

Gain Initial: -30

Final: -10

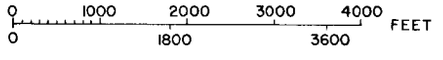
Trip delay: 0·1 s

Compositing: 12 Fold Stack - 24 Traces

VELOCITY INFORMATION

t: Δt., Velocity Spreads, Traverses H and T

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE F

MULTIPLE COVERAGE

RECORDED BY: *Seismic Party No.1*

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

F54/B3-83

TO ACCOMPANY RECORD No. 1967/90

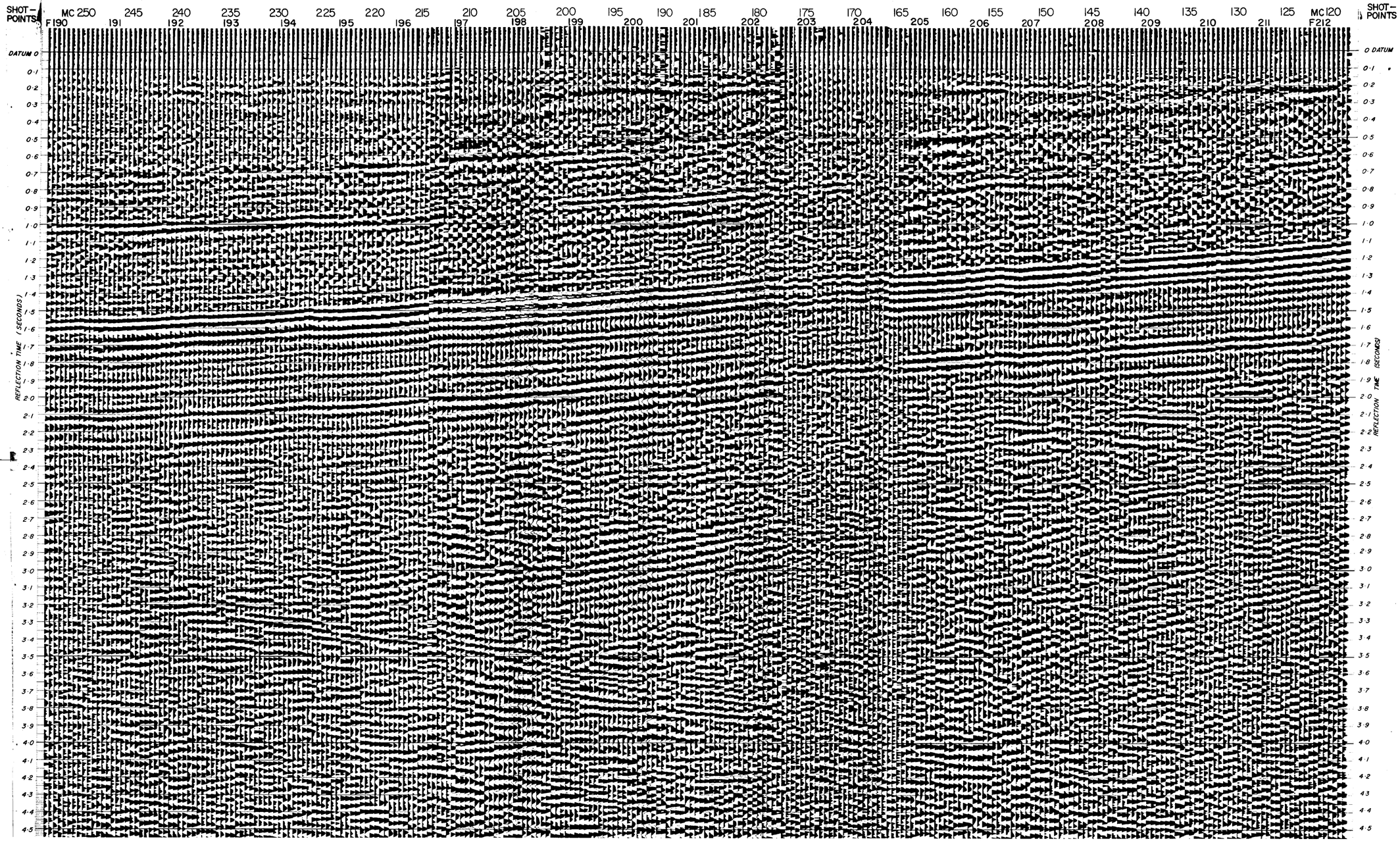
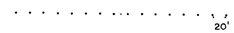


PLATE 60

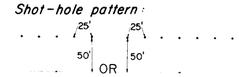
CORRECTED RECORD SECTION
(12 FOLD – 24 TRACES)

RECORDING INFORMATION

Magnetic Recorder DS7 – 7
Amplifiers : 7000 B
Filters : K18 – K92
A.G.C. : W.B.
Gain Initial : – 60 (1 to 12), – 50 (13 to 24)
Final : – 10 to – 30 (Variable)
Geophones : HS-J 14 c/s
Geophone pattern :



Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 1/20 – 1/78
A.G.C. : S.S.
Gain Initial : – 40
Final : – 10
Trip delay : 0·2 s
Compositing : 12 FOLD STACK
24 traces

VELOCITY INFORMATION

t: Δt

VELOCITY SPREADS, TRAVERSES E,U&W

HORIZONTAL SCALE



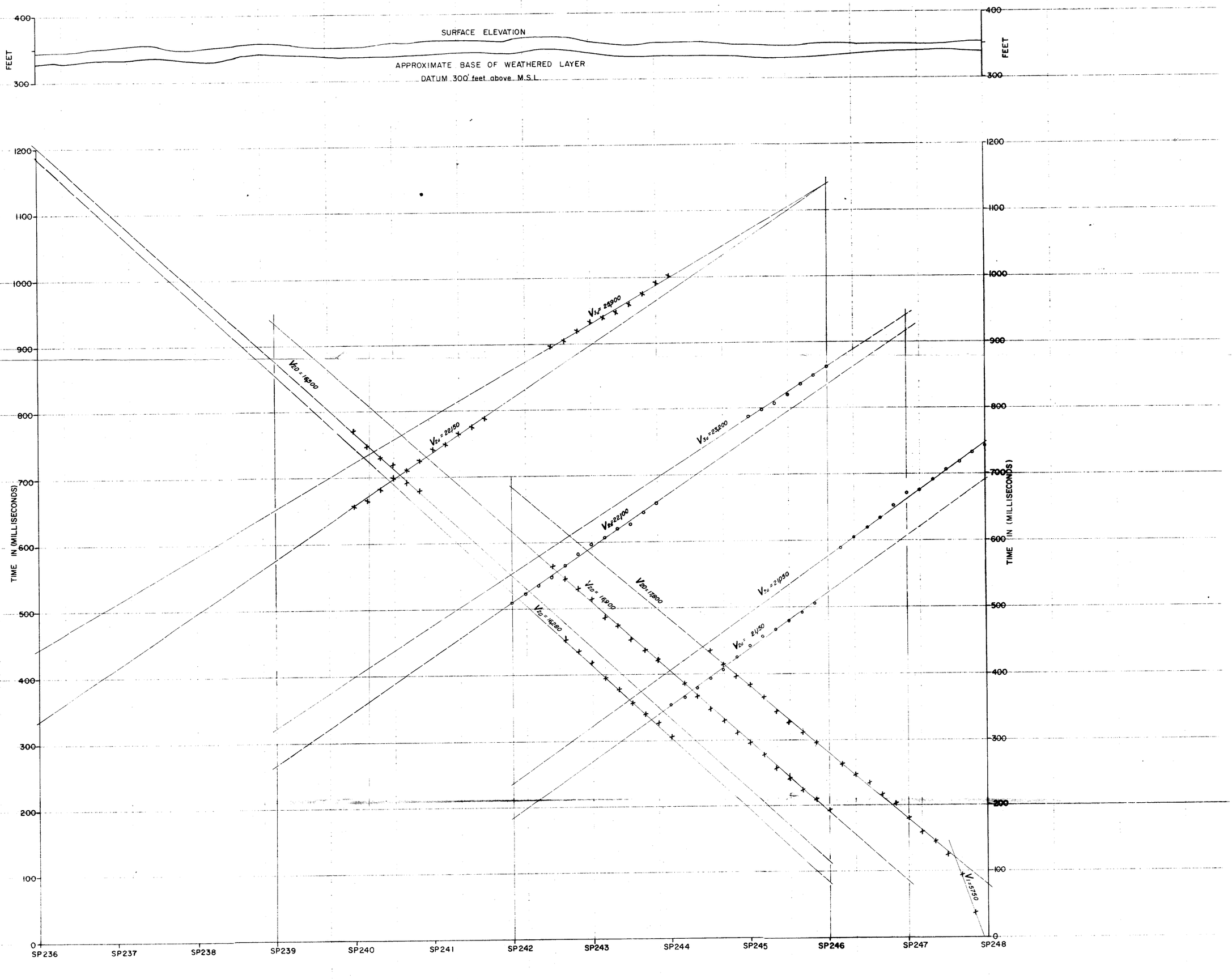
SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

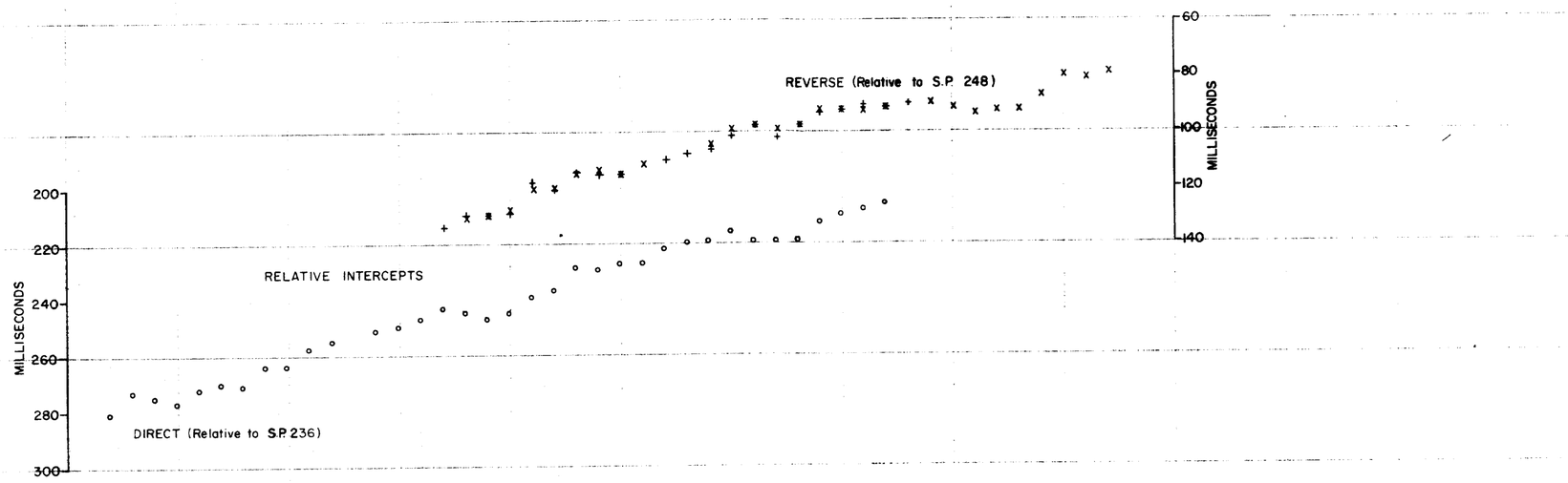
TRAVERSE F
MULTIPLE COVERAGE

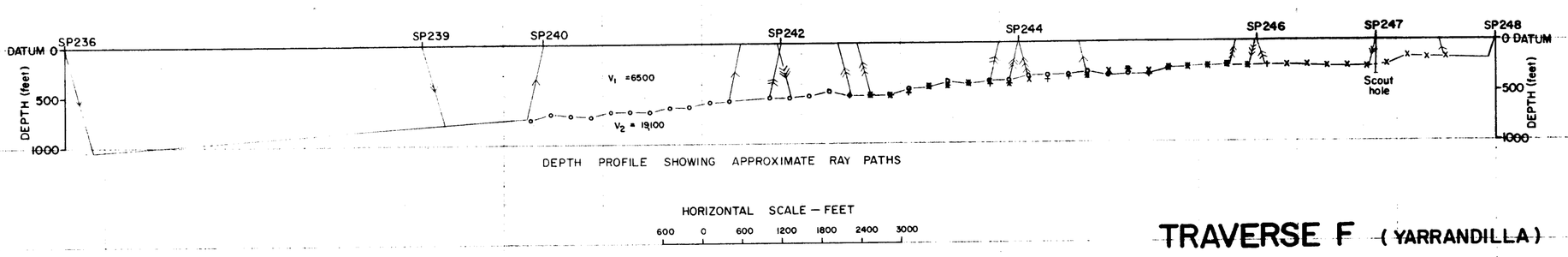
RECORDED BY: *Seismic Party No.1*
SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F54/B3 – 100

TO ACCOMPANY RECORD No.1967/90

PLATE 61







DEPTH PROFILE SHOWING APPROXIMATE RAY PATHS

HORIZONTAL SCALE — FEET

600 0 600 1200 1800 2400 3000

LEGEND

V = 19,100 Seismic velocity (ft/s) in formation

TRAVERSE F (YARRANDILLA)

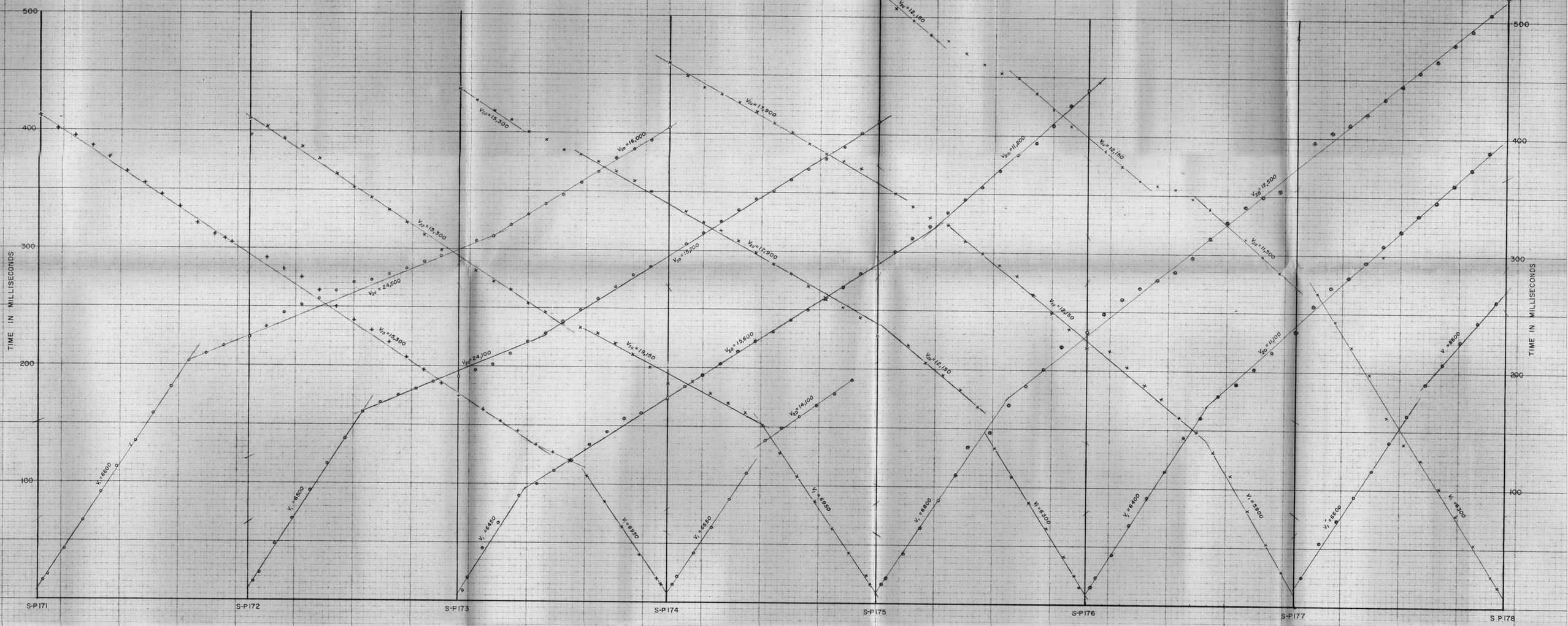
CORRECTED TIME / DISTANCE GRAPH

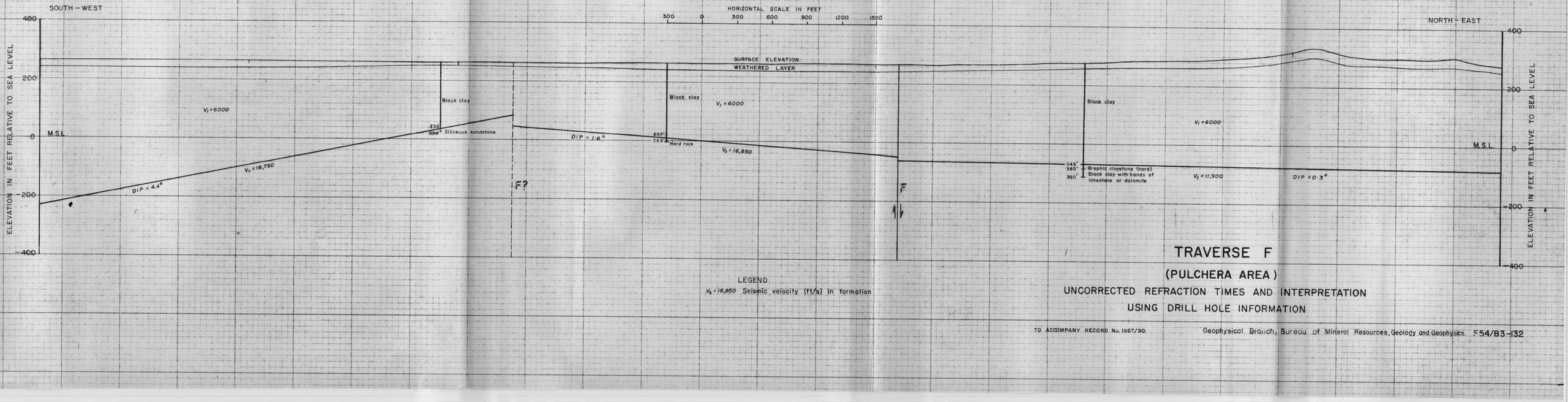
TO ACCOMPANY RECORD No. 1967/90

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F54/B3-151

| S.P. 242 | | |

PLATE 62





LEGEND

$V_2 = 16{,}850$ Seismic velocity (ft/s) in formation

TRAVERSE F

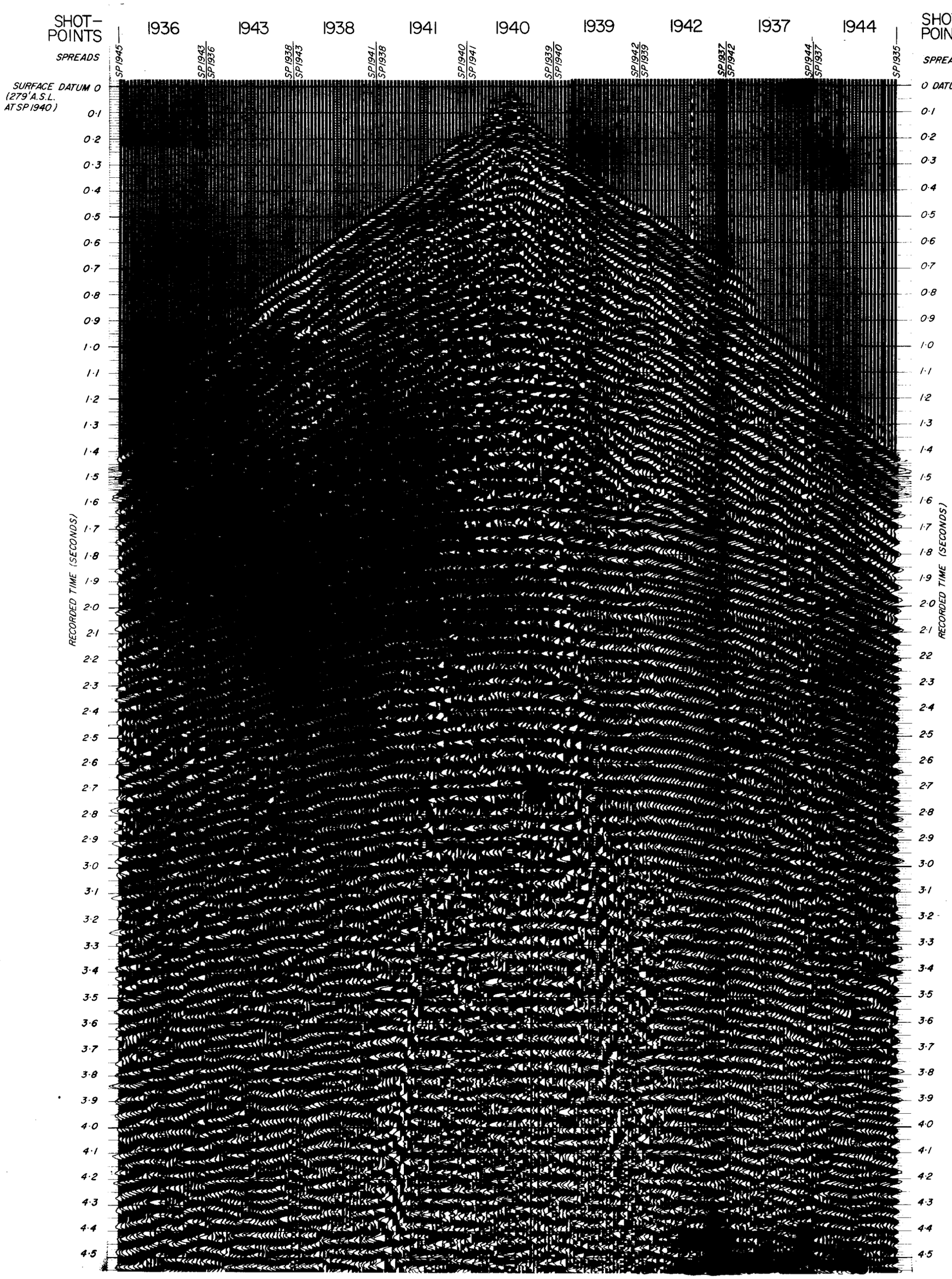
(PULCHERA AREA)

UNCORRECTED REFRACTION TIMES AND INTERPRETATION

USING DRILL HOLE INFORMATION

TO ACCOMPANY RECORD No. 1967/90

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. F54/B3-132



CORRECTED RECORD SECTION

(STATIC CORRECTIONS ONLY)

RECORDING INFORMATION

Magnetic Recorder : DS7 – 7

Amplifiers : 7000 B

Filters : K18 – K160

A.G.C. : W.B.

Gain Initial : –50

Final : –10

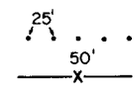
Geophones : HSJ – 14 c/s

Geophone pattern :

16/trace, 20' apart in line

Station interval 150'

Shot-hole pattern :



Depth 40'/42'

Charge 5 x 10 lb

PLAYBACK INFORMATION

Filters : 1/16 – 1/60

A.G.C. : S

Gain Initial : –50

Final : –30

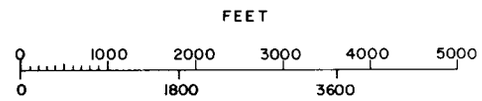
Trip delay : 0 to 0·8 s

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1963

TRAVERSE E

EXTENDED SPREAD VELOCITY SHOOT

RECORDED BY : *Seismic Party No.1*

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

F54/B3–156

TO ACCOMPANY RECORD No. 1967 / 90

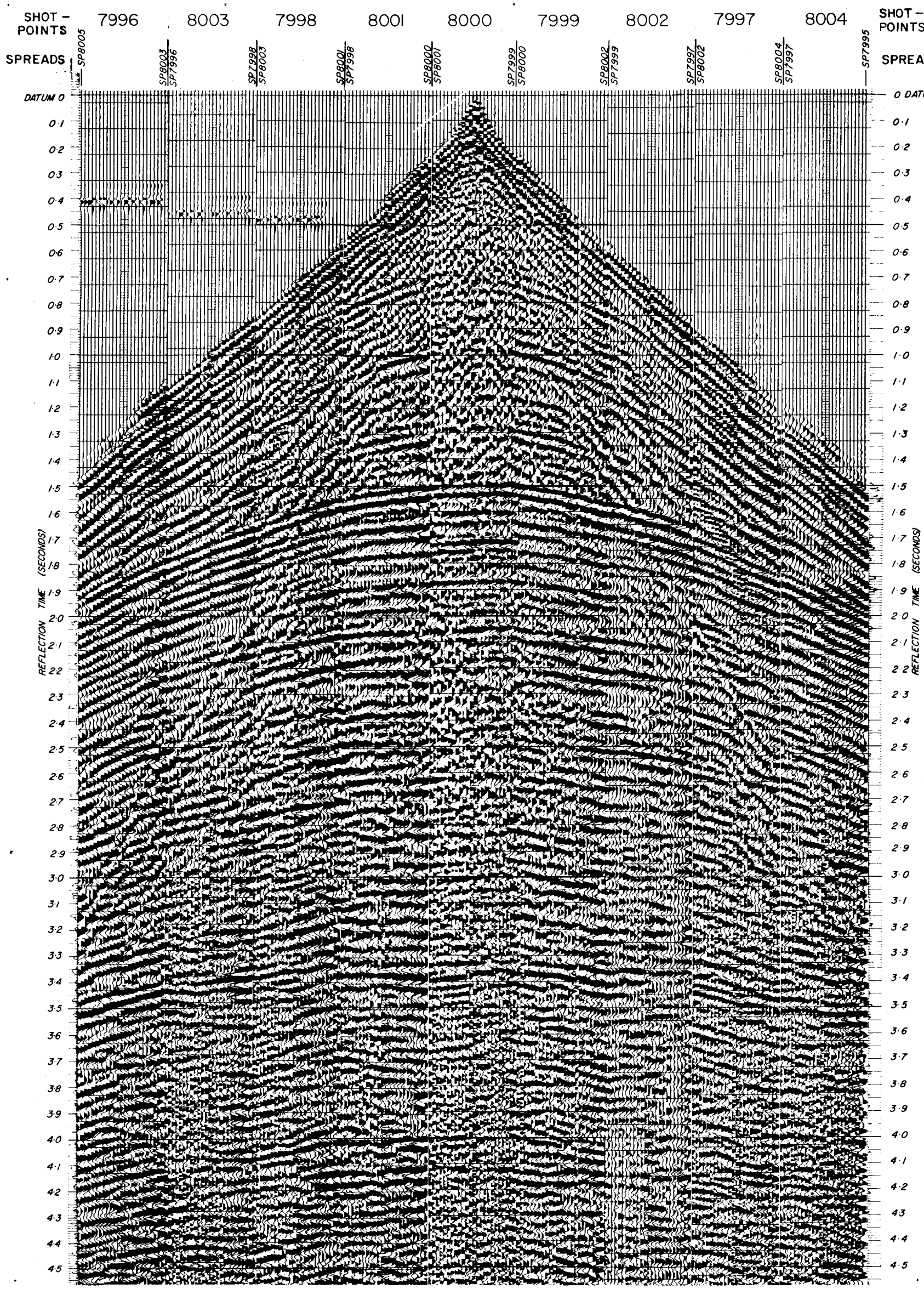


PLATE 64

CORRECTED RECORD SECTION
(STATIC CORRECTIONS ONLY)

RECORDING INFORMATION

Magnetic Recorder DS7-700

Amplifiers : 7000 B

Filters : K18-K92

A.G.C. : W.B.

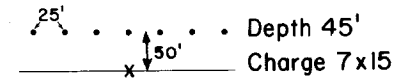
Gain Initial : -55

Final : -20

Geophones : HSJ-14 c/s

Geophone pattern :
16/trace, 10' apart in line

Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 1/18 - 1/60

A.G.C. : S.S.

Gain Initial : -40

Final : -30

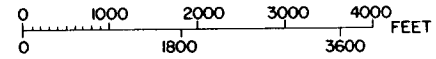
Trip delay : ·2 to 0·8 s

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE U

EXTENDED SPREAD VELOCITY SHOOT

RECORDED BY: *Seismic Party No.1*

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

F54/B3-102

TO ACCOMPANY RECORD No. 1967/90

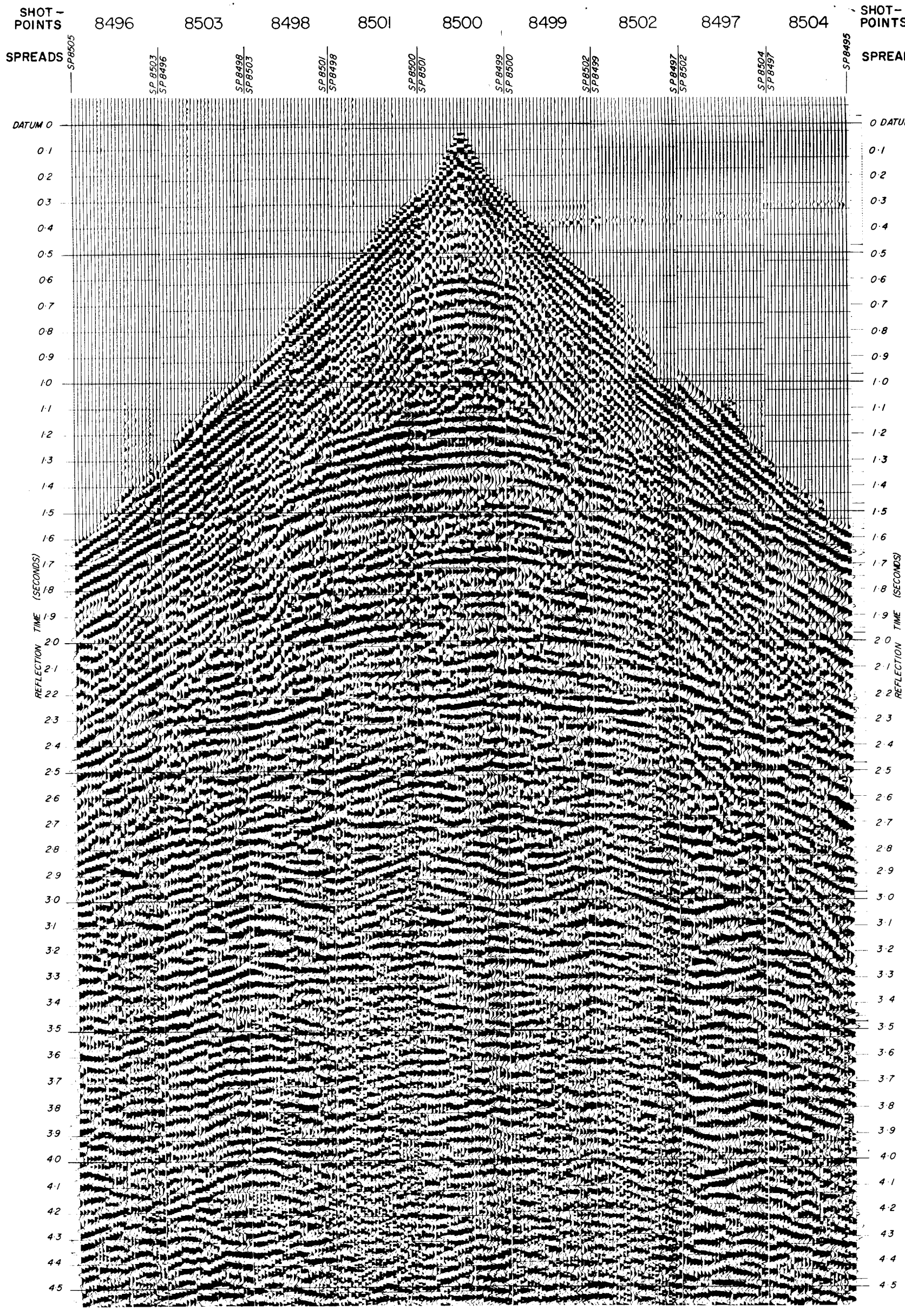


PLATE 65

CORRECTED RECORD SECTION
(STATIC CORRECTIONS ONLY)

RECORDING INFORMATION

Magnetic Recorder DS7-700

Amplifiers : 7000 B

Filters : K18-K92

A.G.C. : W.B.

Gain Initial : -55

Final : - 20

Geophones : HSJ - 14 c/s

Geophone pattern :
24/trace, 10' apart in line
Station interval 150'

Shot-hole pattern :
25'
Depth 45'
50'
Charge 5 x 10

PLAYBACK INFORMATION

Filters : 1/20 - 1/60

A.G.C. : S.S.

Gain Initial : -40

Final : -30

Trip delay : 0·2 to 0·8s

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

0 1000 2000 3000 4000 FEET
0 1800 3600

SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

TRAVERSE W

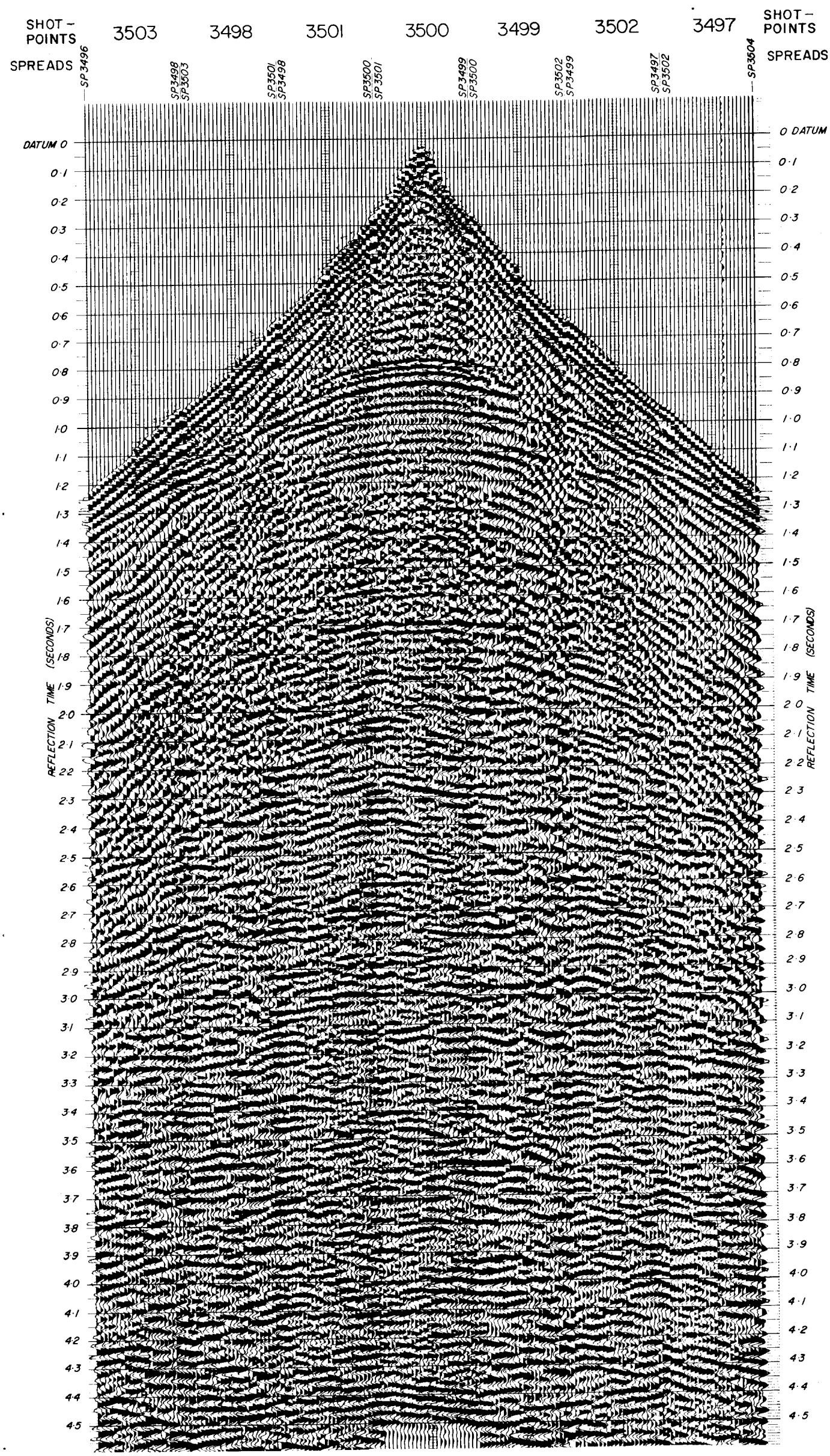
EXTENDED SPREAD VELOCITY SHOOT

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F54/83-106

TO ACCOMPANY RECORD No. 1967/90

PLATE No. 66



CORRECTED RECORD SECTION
(STATIC CORRECTIONS ONLY)

RECORDING INFORMATION

Magnetic Recorder DS7-700

Amplifiers : 7000 B

Filters : K18-K92

A.G.C. : W.B.

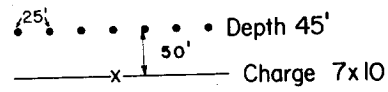
Gain Initial : -55

Final : -20

Geophones : HSJ-14 c/s

Geophone pattern :
24/ trace, 10' apart in line
Station interval 150'

Shot-hole pattern :



PLAYBACK INFORMATION

Filters : 1/20-1/60

A.G.C. : S.S.

Gain Initial : -40

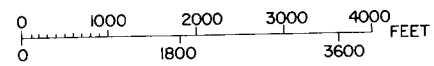
Final : -20

Trip delay : 0·2 to 0·8 s

Compositing : Nil

VELOCITY INFORMATION

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN
SEISMIC SURVEY 1964

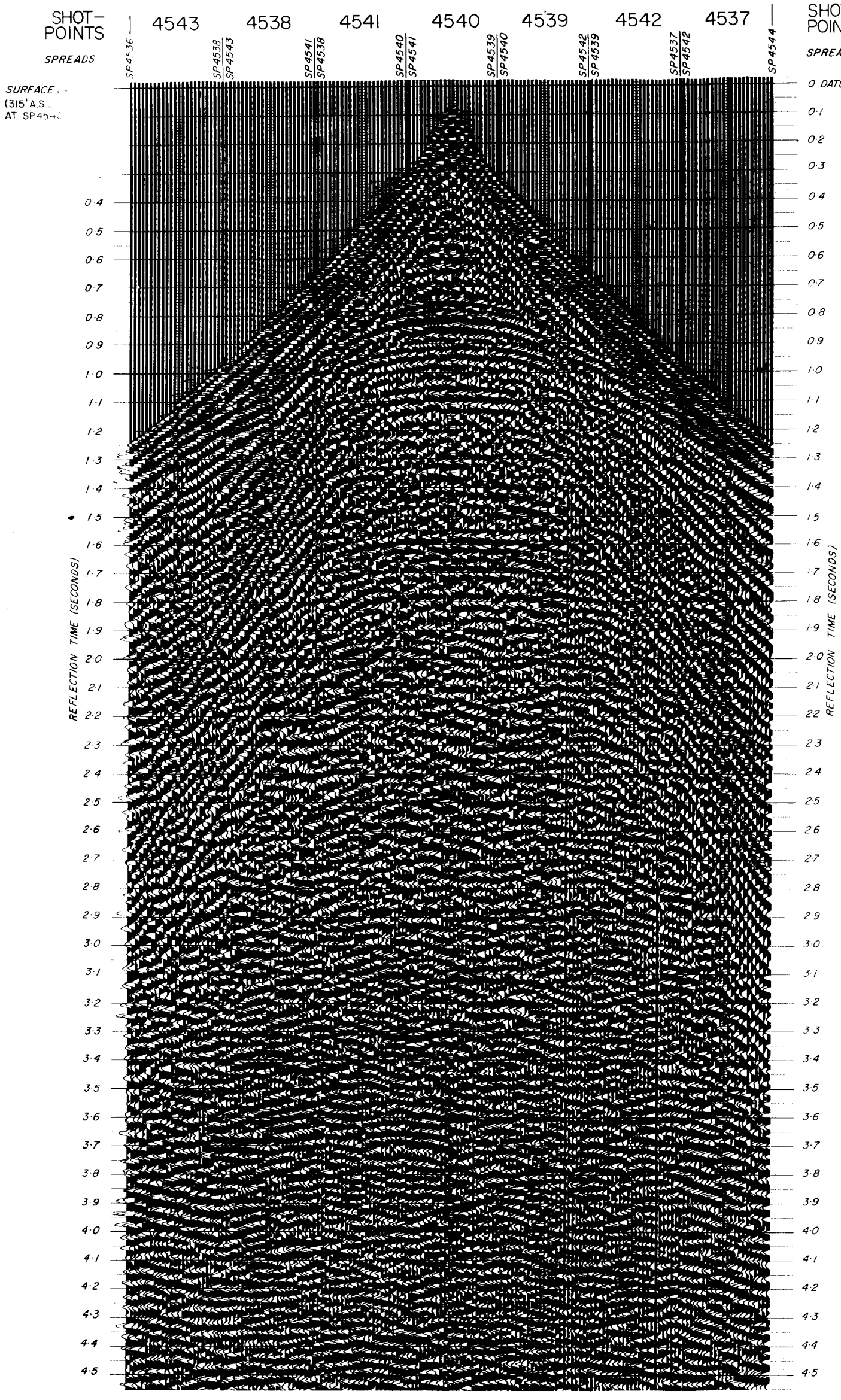
TRAVERSE T

EXTENDED SPREAD VELOCITY SHOOT

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F54/B3-103

TO ACCOMPANY RECORD No. 1967/90



CORRECTED RECORD SECTION
(STATIC CORRECTIONS ONLY)

RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 7000B

Filters : K18 – K160

A.G.C. : W.B.

Gain Initial : -55

Final : -10

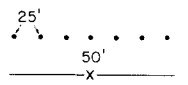
Geophones : HSJ – 14 c/s

Geophone pattern :

16/trace, 10' apart in line

Station interval 150'

Shot-hole pattern :



Depth 45'

Charge 7 x 5 lb

PLAYBACK INFORMATION

Filters : 1/16 – 1/60

A.G.C. : S.S.

Gain Initial : -40

Final : -20

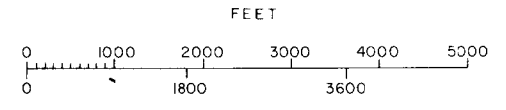
Trip delay : 0 to 0·4 s

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1963

TRAVERSE H

EXTENDED SPREAD VELOCITY SHOOT

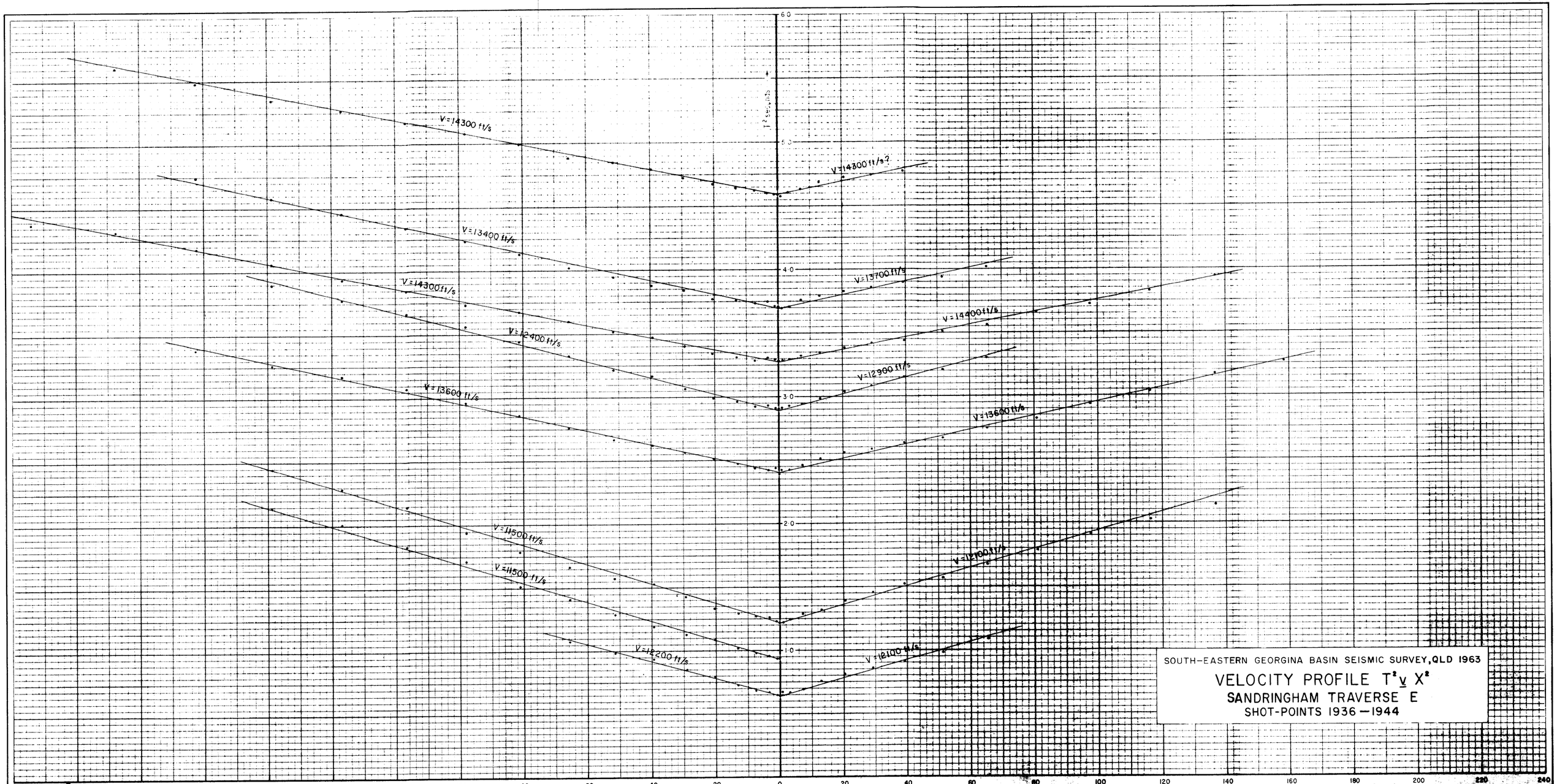
RECORDED BY : *Seismic Party No.1*

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

TO ACCOMPANY RECORD No. 1967/90

F54/B3-155

PLATE 68



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963

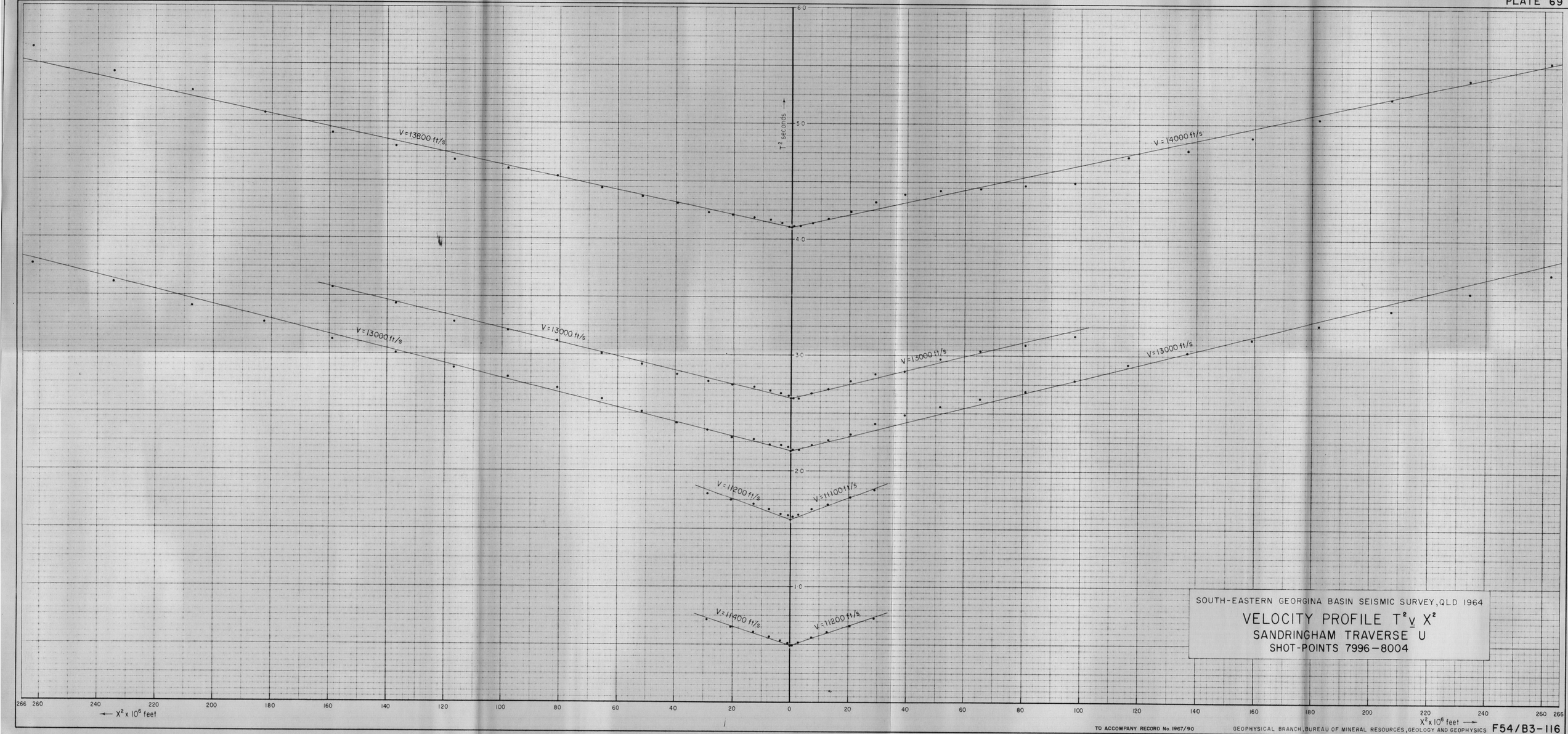
VELOCITY PROFILE $T^2 \underline{v} X^2$

SANDRINGHAM TRAVERSE E

SHOT-POINTS 1936 — 1944

TO ACCOMPANY RECORD No. 1967/90

F54/82-113



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1964

VELOCITY PROFILE T^2_V X^2

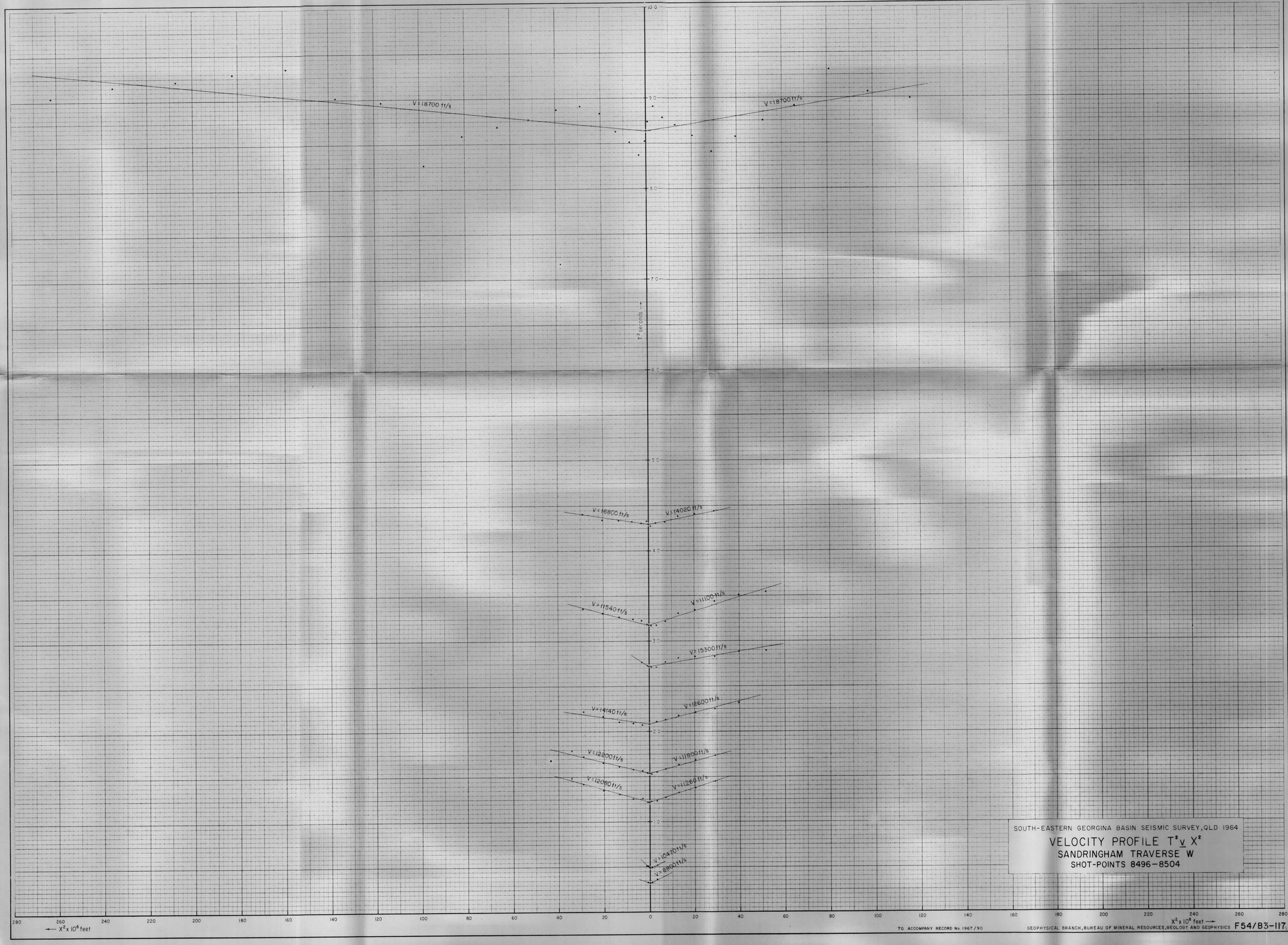
SANDRINGHAM TRAVERSE U

SHOT-POINTS 7996–8004

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-116

PLATE 70



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1964

VELOCITY PROFILE $T^2 \underline{v} X^2$

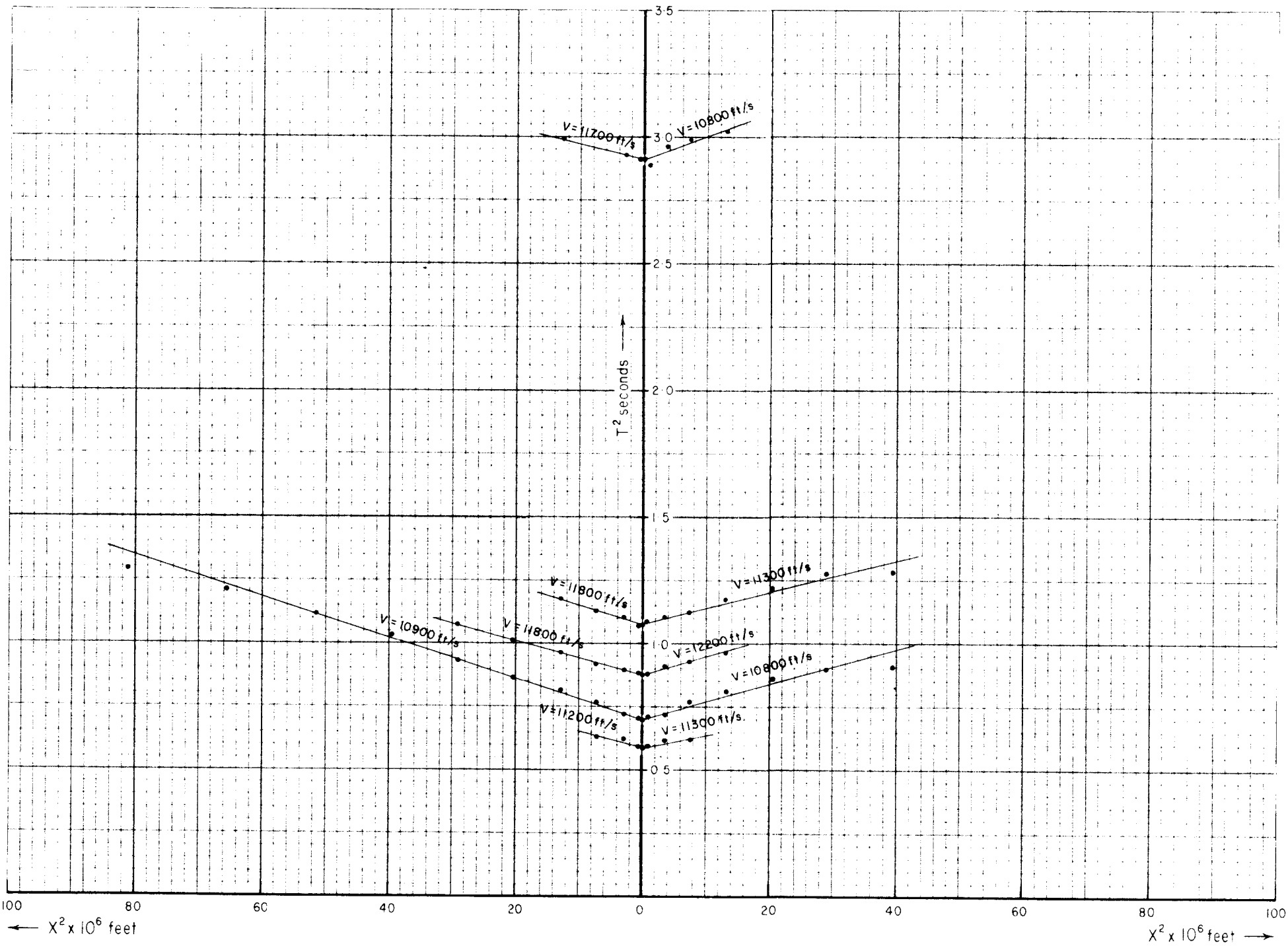
SANDRINGHAM TRAVERSE W

SHOT-POINTS 8496–8504

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-117

PLATE 71



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1964

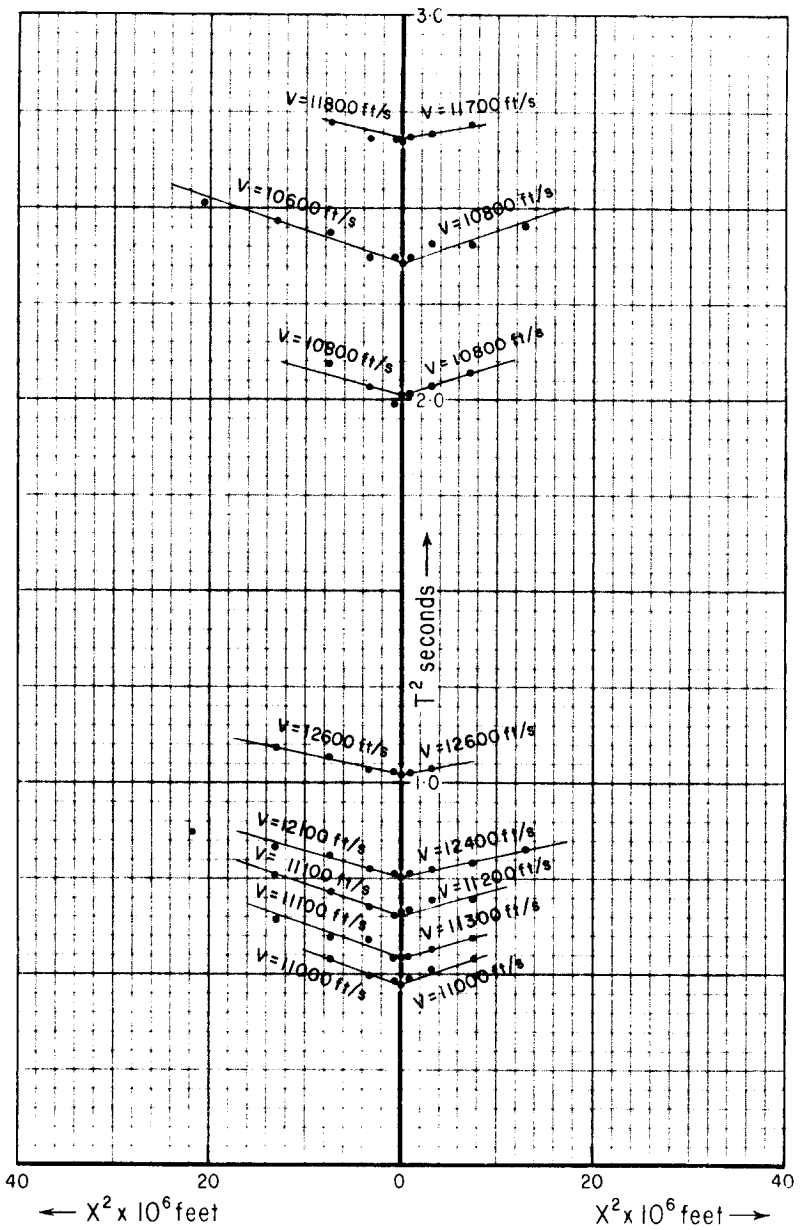
VELOCITY PROFILE $T^2 \underline{v} X^2$

SANDRINGHAM TRAVERSE T

SHOT-POINTS 3497—3503

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-115



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963

VELOCITY PROFILE T^2 v X^2

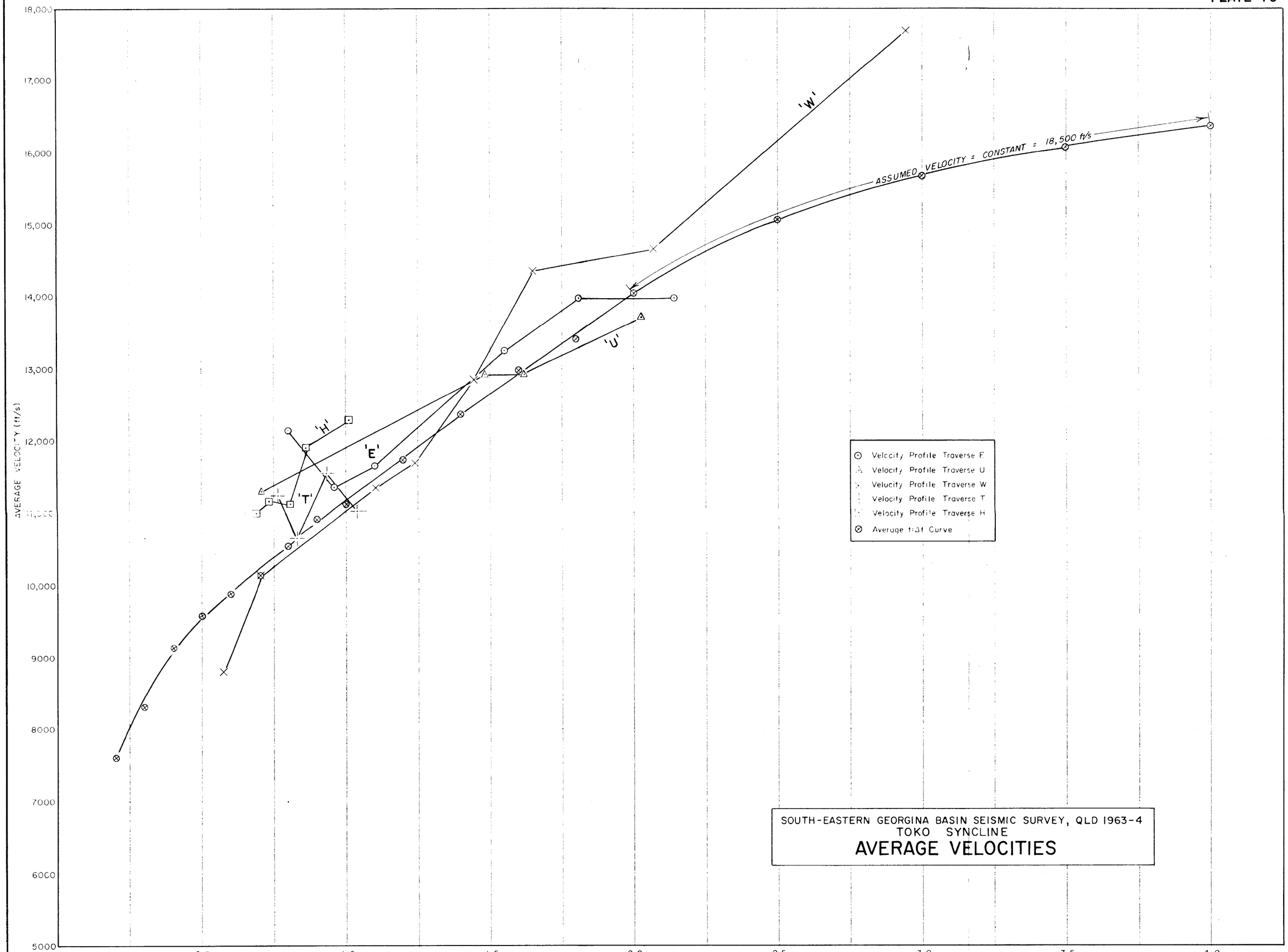
SANDRINGHAM TRAVERSE H

SHOT-POINTS 4536–4544

TO ACCOMPANY RECORD No. 1967/90

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F54/B3-114

PLATE 73



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963-4
TOKO SYNCLINE

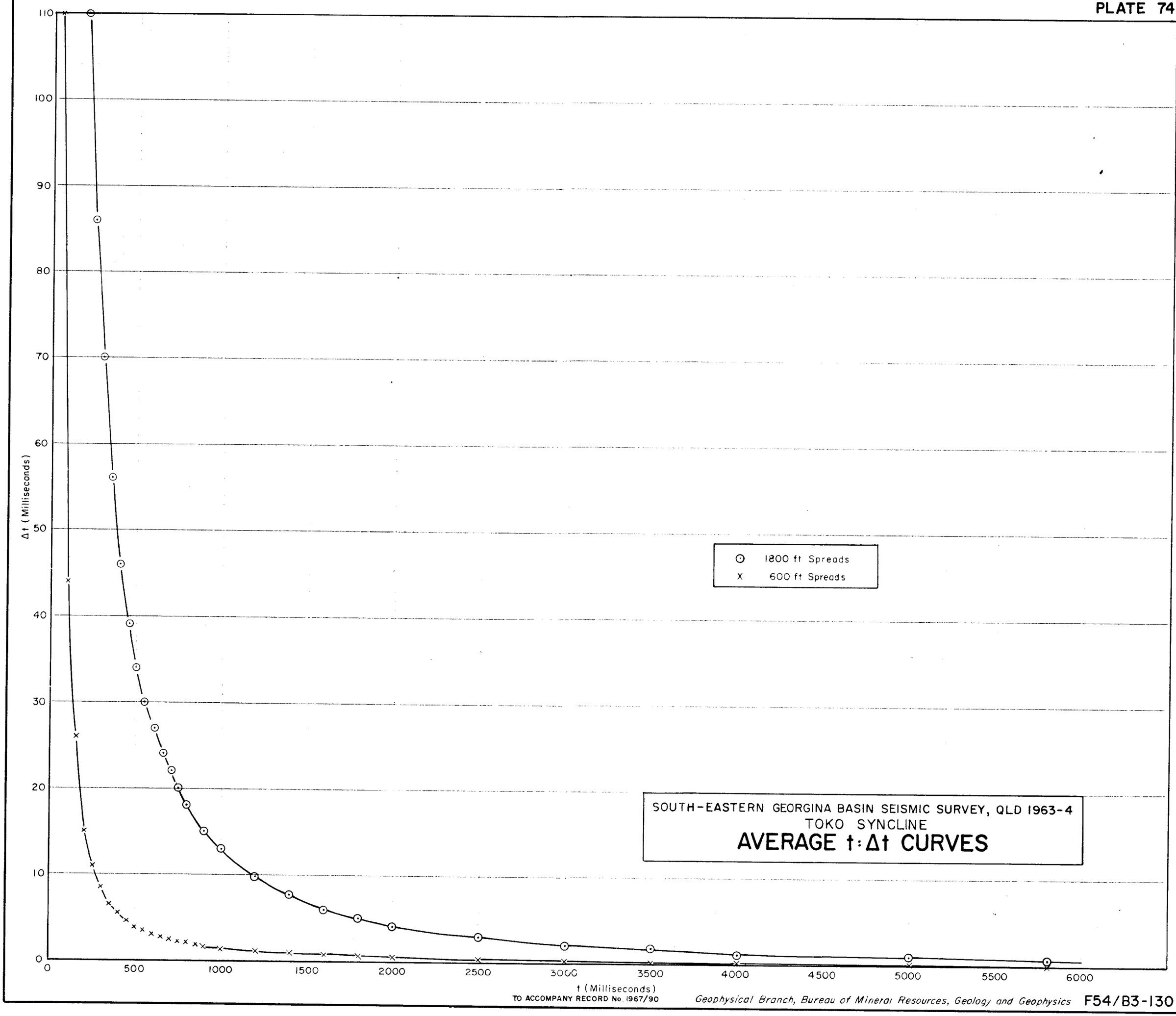
AVERAGE VELOCITIES

TO ACCOMPANY RECORD No. 1967/90

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

F54/83-131

PLATE 74



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963-4

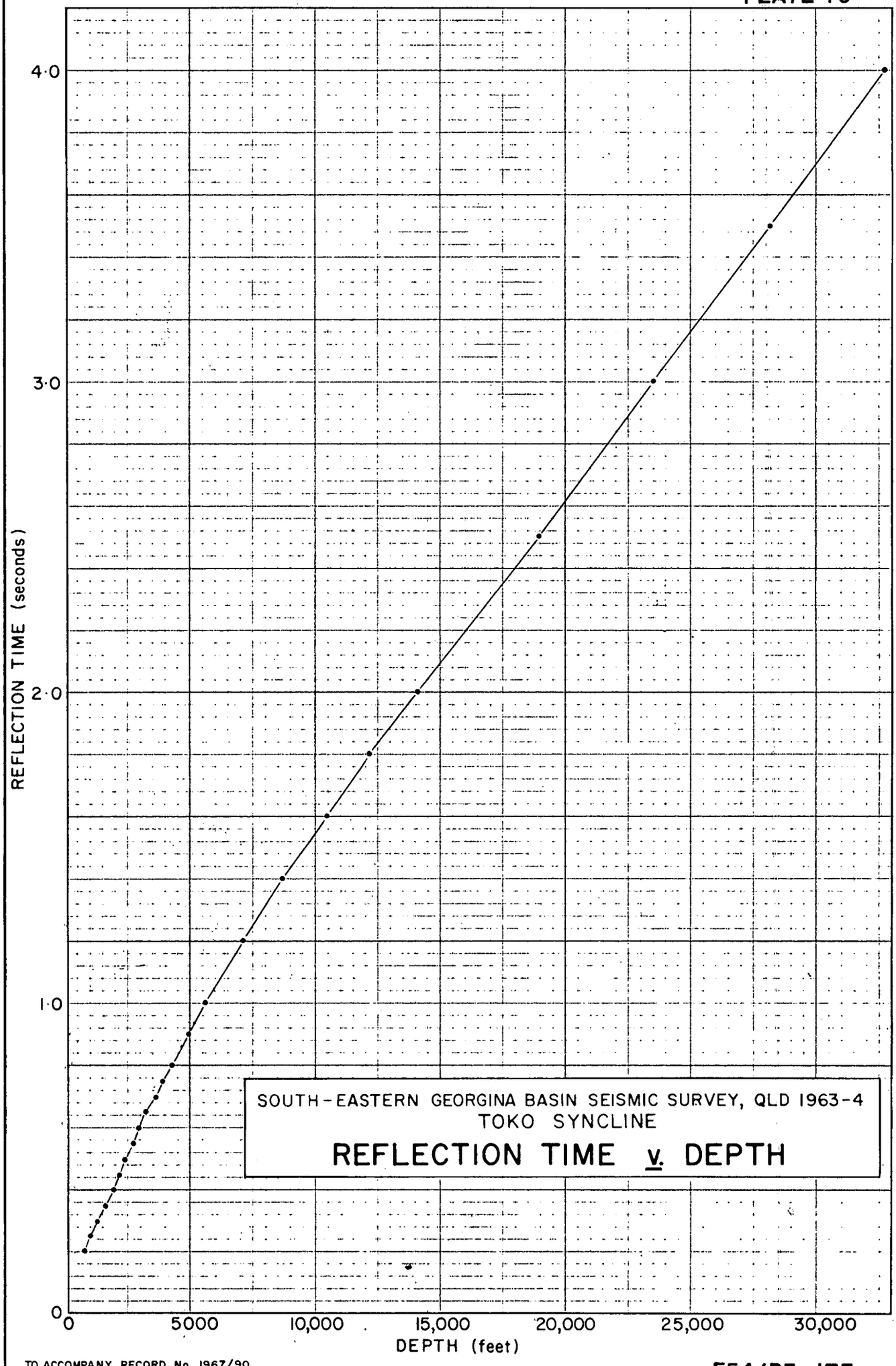
TOKO SYNCLINE

AVERAGE t:Δt CURVES

TO ACCOMPANY RECORD No. 1967/90

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F54/B3-130

PLATE 75



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963-4
TOKO SYNCLINE

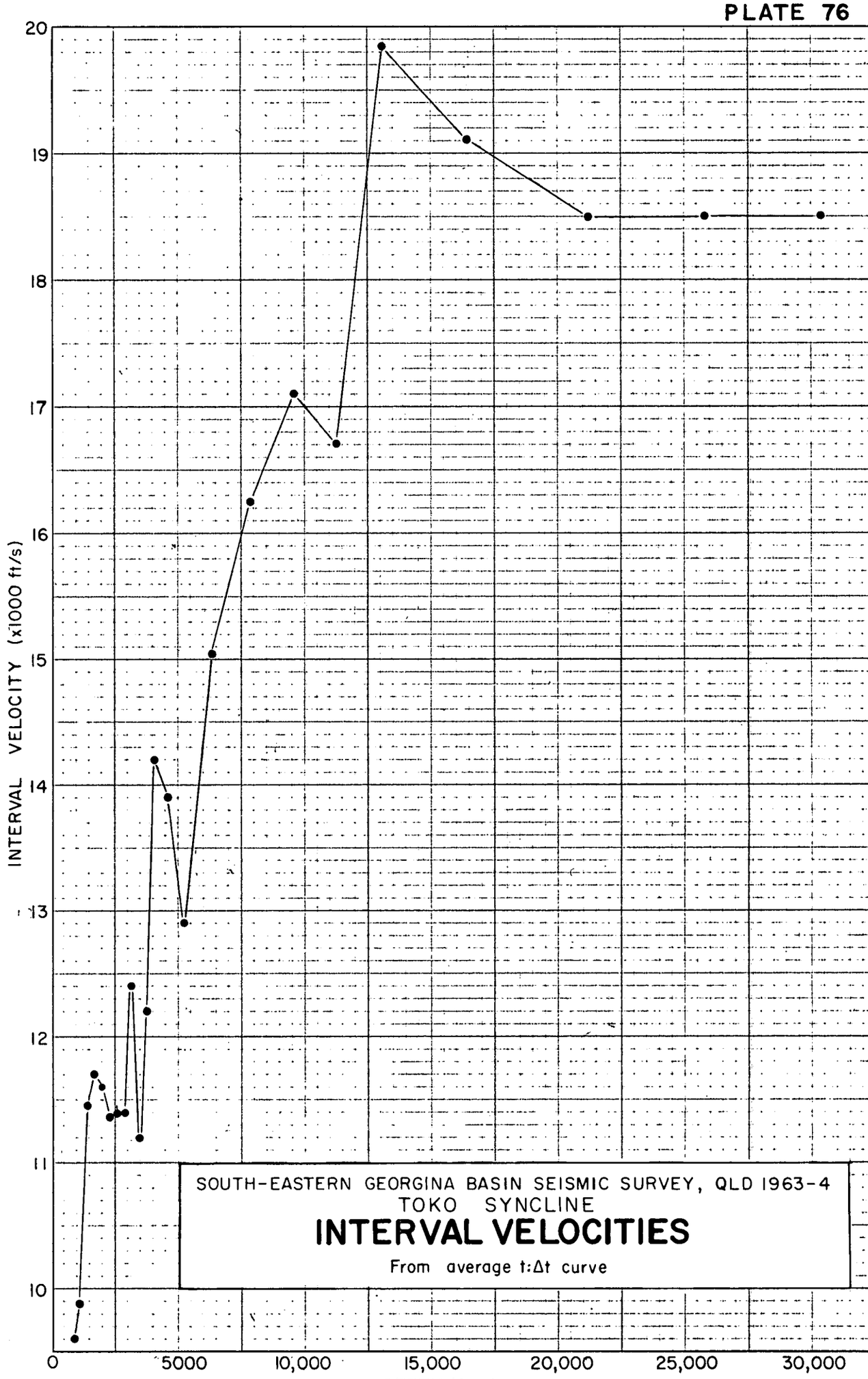
REFLECTION TIME v. DEPTH

TO ACCOMPANY RECORD No. 1967/90

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

F54/B3-173

PLATE 76



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY, QLD 1963-4

TOKO SYNCLINE

INTERVAL VELOCITIES

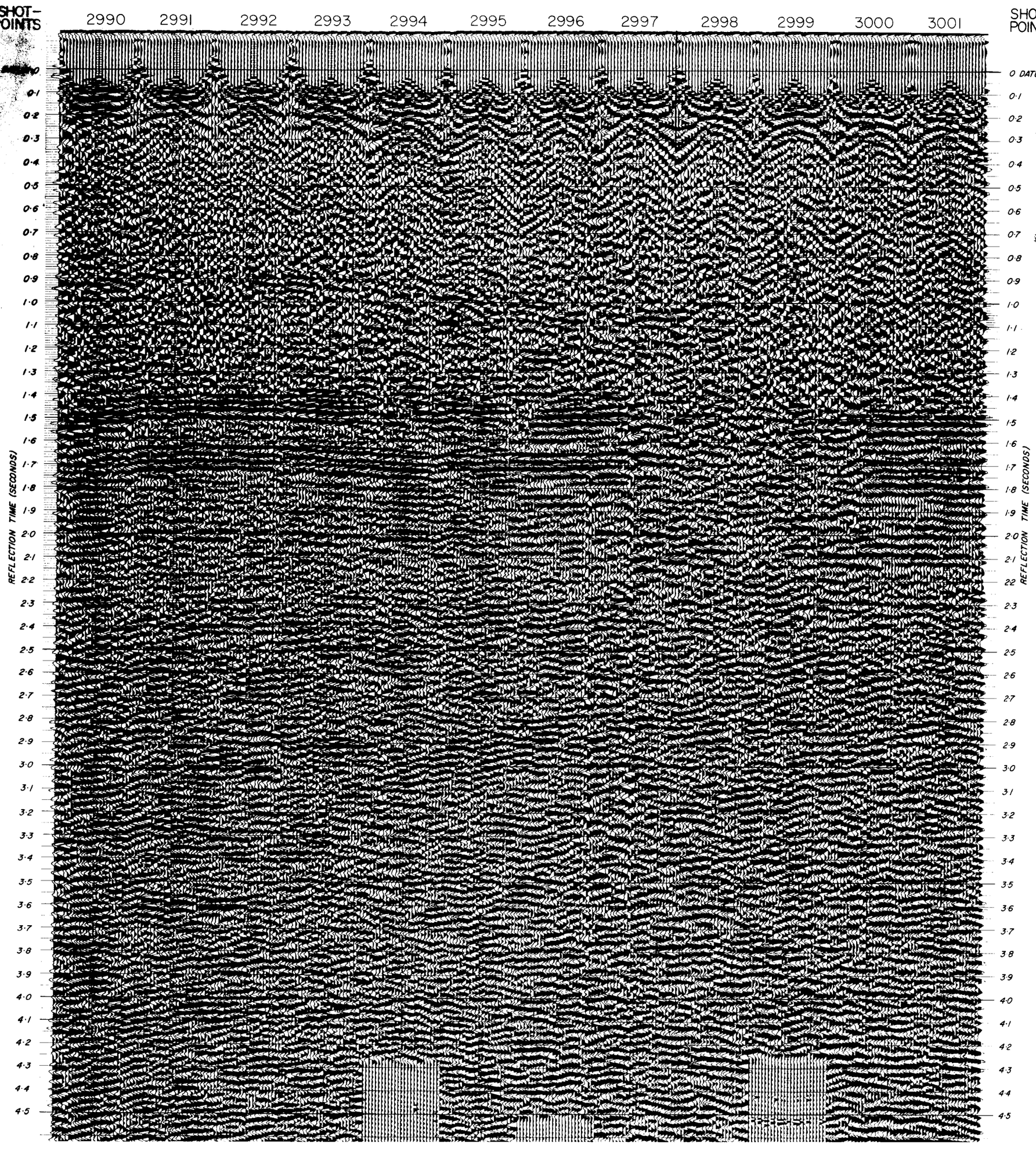
From average t:Δt curve

TO ACCOMPANY RECORD No. 1967/90

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

F54/B3-174

PLATE 77



CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7 – 7

Amplifiers : 7000B

Filters : K18 – K160

A.G.C. : W.B.

Gain Initial : –55

Final : –10

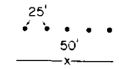
Geophones : HSJ – 14 c/s

Geophone pattern :

16/trace, 10' apart in line

Station interval 150'

Shot-hole pattern :



Depth 45'

Charge 2½ to 5 lb/hole

PLAYBACK INFORMATION

Filters : 1/20 – 1/60

A.G.C. : S.S.

Gain Initial : –40

Final : –20

Trip delay : 0

Compositing : Nil

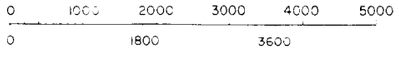
VELOCITY INFORMATION

t:Δt analysis and

Expanded Spread Velocity Shoot

Traverses E, U, W, T, H

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1963

TRAVERSE M

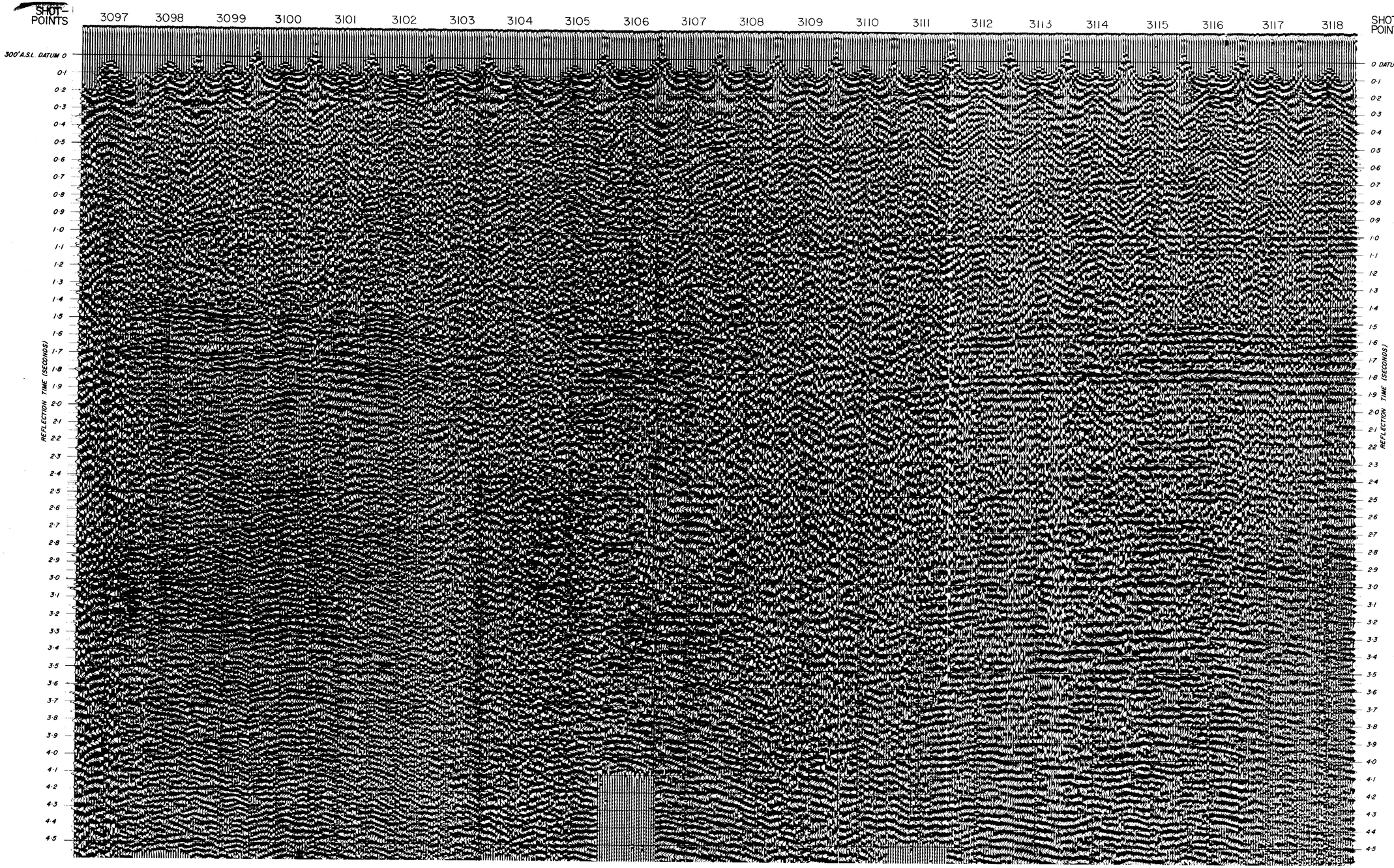
RECORDED BY : *Seismic Party No 1*

SECTION BY : *Bureau of Mineral Resources*

Playback Centre SIE MS 42

TO ACCOMPANY RECORD No. 1967 / 90

F54/B3 – 139



CORRECTED RECORD SECTION

PLATE

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 7000B

Filters: K18-K160

A.G.C.: W.B.

Gain Initial: -55

Final: -10

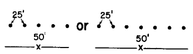
Geophones: HSJ-14c/s

Geophone pattern:

16/trace, 10' apart in line

Station interval 150'

Shot-hole pattern:



Depth 45'

Charge 2½ to 5 lb/hole

PLAYBACK INFORMATION

Filters: 1/20-1/60

A.G.C.: S.S.

Gain Initial: -40

Final: -20

Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

t:Δt analysis and

Expanded Spread Velocity Shoot

Traverses E, U, W, T, H

HORIZONTAL SCALE

FEET

0 1000 2000 3000 4000 5000

0 1800 3600

SOUTH-EASTERN GEORGINA BASIN

SEISMIC SURVEY 1963

TRAVERSE L

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources*

Playback Centre SIE MS 42

TO ACCOMPANY RECORD No. 1967/90

F54/B3-142

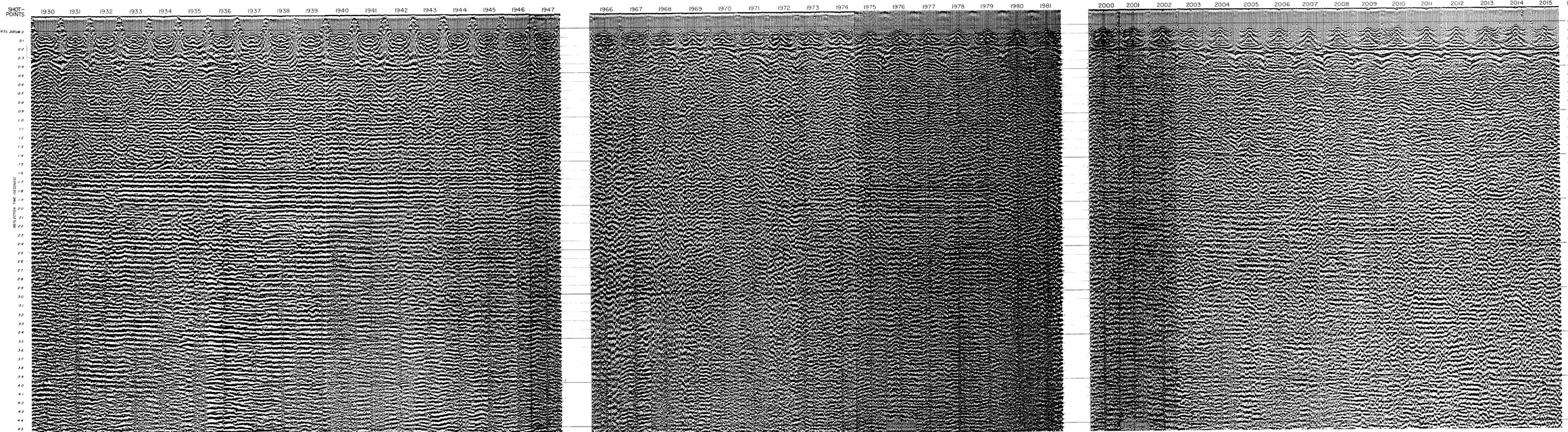


PLATE 79

CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 7000B

Filters: K18-K160

A.G.C.: W.B.

Gain Initial: -55

Final: -10

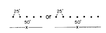
Geophones: HSJ-14c/s

Geophone pattern:

16/trace 10' apart in line, 50' offset

Station interval 150'

Shot-hole pattern:



Depth 45'

Charge 2½ to 5 lb/hole

PLAYBACK INFORMATION

Filters: 1/20-1/60

A.G.C.: S.S.

Gain Initial: -40

Final: -20

Trip delay: 0

Compositing: Nil

VELOCITY INFORMATION

t∆t analysis and

Expanded Spread Velocity Shoot

Traverses E,U,W,T,H

HORIZONTAL SCALE

FEET

0 1000 2000 3000 4000 5000

0 1800 3600

SOUTH-EASTERN GEORGINA BASIN

SEISMIC SURVEY 1963

TRAVERSE E

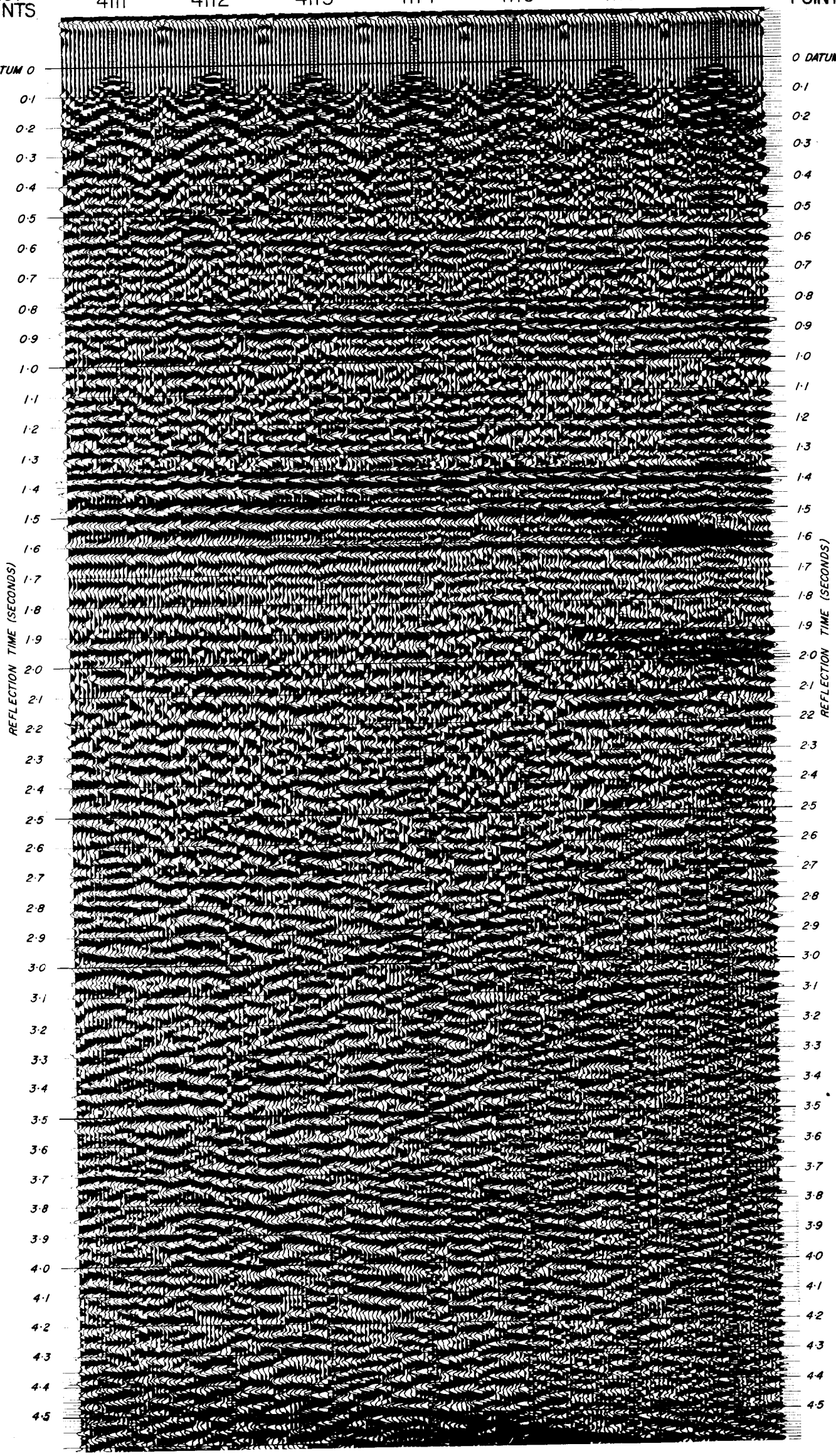
RECORDED BY: *Seismic Party No. 1*

SECTION BY: *Bureau of Mineral Resources*

Playback Centre S.E. MS 42

TO ACCOMPANY RECORD No. 1967/90

F54/B3-143



CORRECTED RECORD SECTION

PLATE 80

RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 7000B

Filters : K18 – K160

A.G.C. : W.B.

Gain Initial : -55

Final : -10

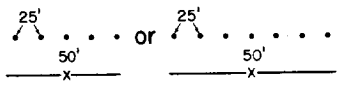
Geophones : HSJ – 14 c/s

Geophone pattern :

16/trace, 20' apart in line

Station interval 150'

Shot-hole pattern :



Depth 45'

Charge 2½ to 5 lb/hole

PLAYBACK INFORMATION

Filters : 1/20 – 1/60

A.G.C. : S.S.

Gain Initial : -40

Final : -20

Trip delay : 0

Compositing : Nil

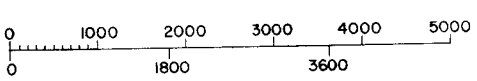
VELOCITY INFORMATION

t:Δt analysis and

Expanded Spread Velocity Shoot

Traverses E,U,W,T,H

HORIZONTAL SCALE



SOUTH-EASTERN GEORGINA BASIN SEISMIC SURVEY 1963

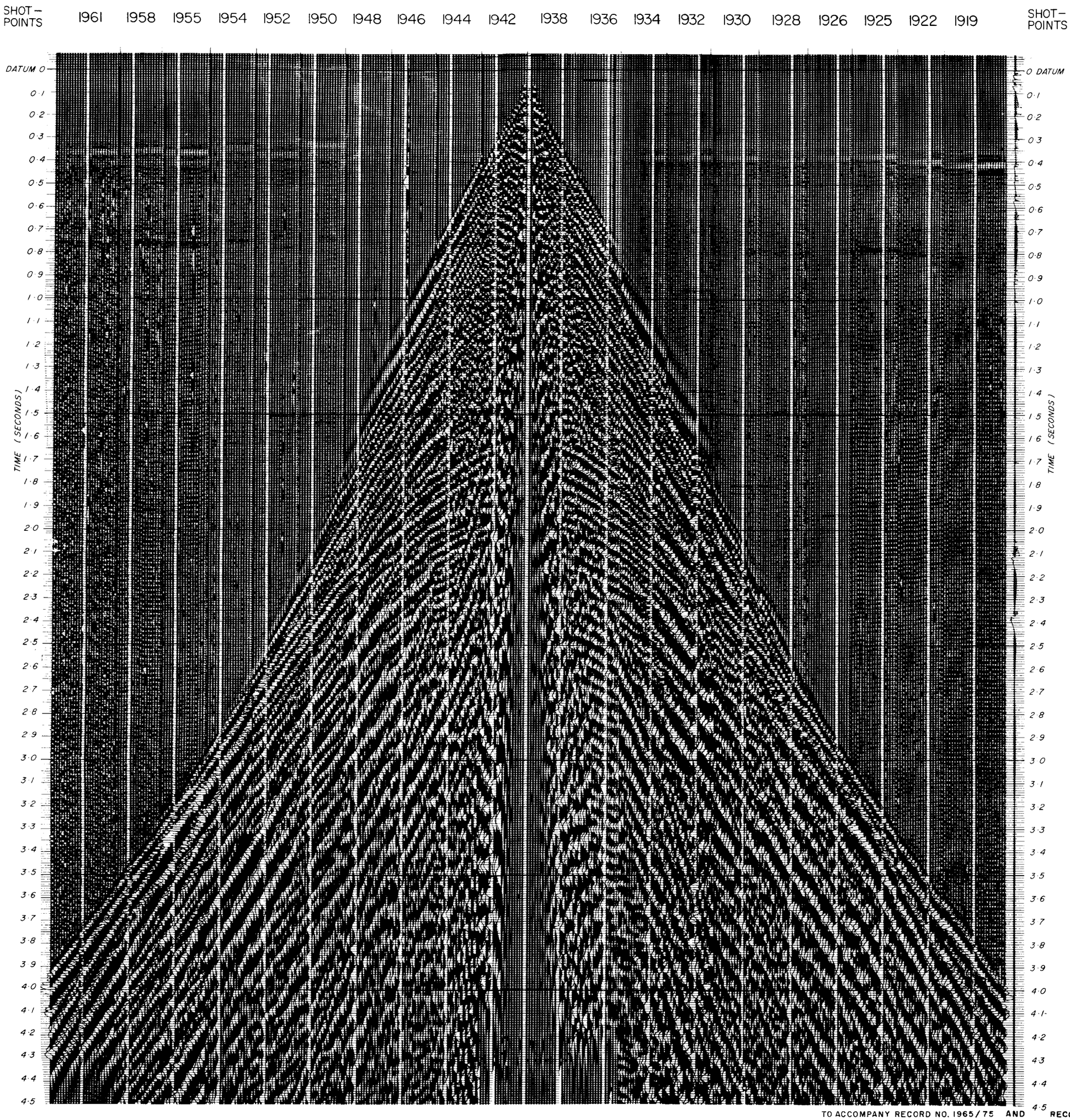
TRAVERSE G

RECORDED BY : *Seismic Party No.1*

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

TO ACCOMPANY RECORD No. 1967/90

F54/B3-140



RECORD SECTION
(REFRACTION DEPTH PROBE PROFILES)

RECORDING INFORMATION

Magnetic Recorder : DS7–700

Amplifiers : 7000 B

Filters : Out

A.G.C. : Nil

Gain Initial : Varied 6–8

Final :

Geophones : Electro Tech 4·5 c/s

Geophone pattern : 4/trace, 22' apart in line perp. to traverse

Shot-hole pattern :
1 to 5 holes, 50' apart in line perp. to traverse
Depth 60'

PLAYBACK INFORMATION

Filters : Out – K78

A.G.C. : S.S.

Gain Initial : –20

Final : –20

Trip delay : –

Compositing : Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

0 1000 2000 4000 6000 FEET
0 1800 3600 5400

S.E. GEORGINA BASIN
SEISMIC SURVEY 1963
VARIABLE-AREA REFRACTION DEPTH PROBE PROFILES
TRAVERSE E

RECORDED BY: *Seismic Party No.1*

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

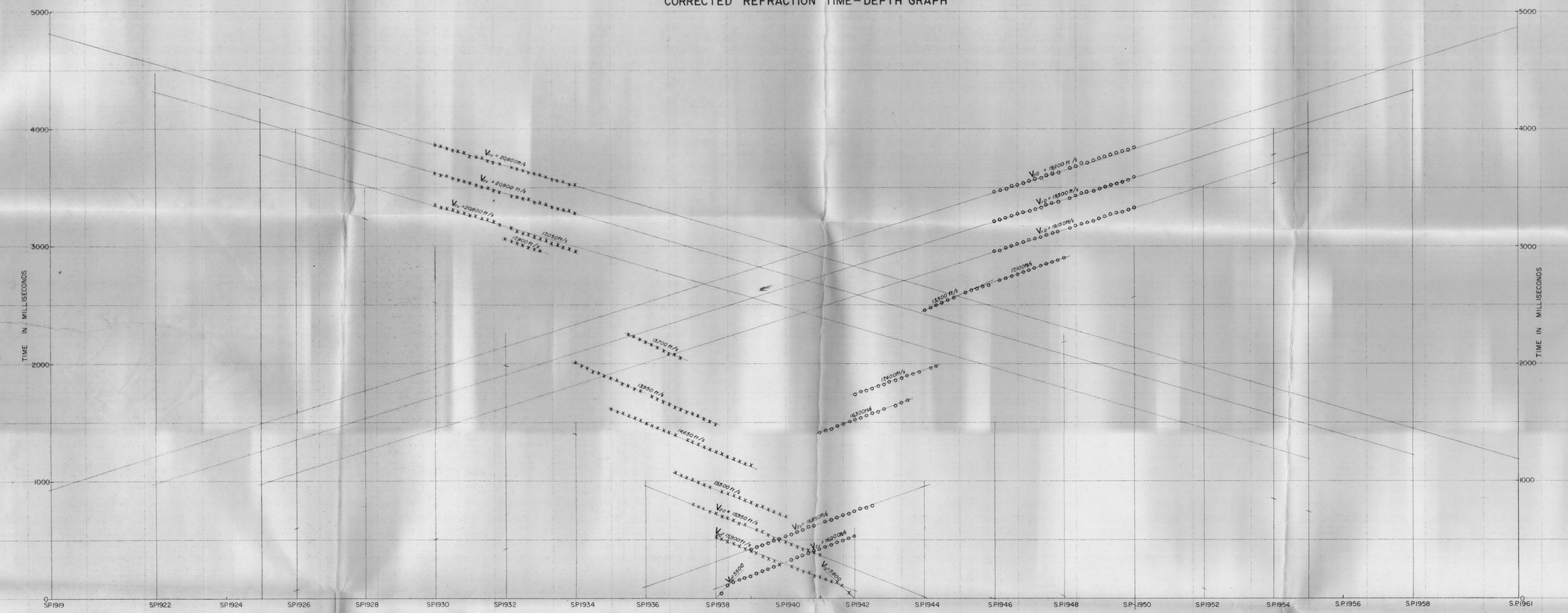
F54/83-101

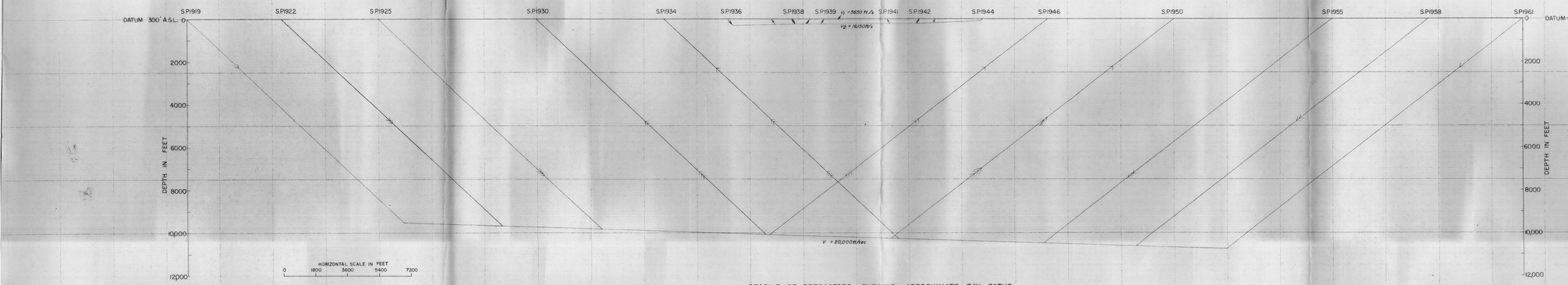
TO ACCOMPANY RECORD NO. 1965/75 AND RECORD No. 1967/90



TRAVERSE E

CORRECTED REFRACTION TIME-DEPTH GRAPH





PROFILE OF REFRACTORS SHOWING APPROXIMATE RAY PATHS

S.P.1919

to	3461	3478	3487	3505	3524	3534	3546	3563	3575	3598	3614	3624	–	3658	3675	3703	3708	3731	3745	3763	3778	3791	3799	3816	3831
Wc+Ec	−9	−9	−9	−10	−10	−10	−10	−10	−10	−9	−9	−9	−9	−9	−9	−9	−9	−9	−9	−9	−9	−9	−9	−9	−9
fc	3470	3487	3496	3515	3534	3544	3556	3573	3585	3607	3623	3633	–	3667	3684	3712	3717	3740	3754	3772	3787	3800	3808	3825	3840
	1946						1947						1948						1949						1950

S.P.1922

to	3214	3227	3240	3254	3271	3282	3295	3311	3324	3545	3360	3371	–	3406	3429	3445	3455	3477	3493	3510	3526	3537	3548	3566	3581
Wc+Ec	−8	−8	−8	−9	−9	−9	−9	−9	−8	−8	−8	−8	−8	−8	−8	−8	−8	−8	−8	−8	−8	−8	−8	−8	−8
fc	3222	3235	3248	3263	3280	3291	3304	3320	3333	3553	3368	3379	–	3414	3437	3453	3463	3485	3501	3518	3534	3545	3556	3574	3589
	1946						1947						1948						1949						1950

S.P.1925

to	2949	2960	2979	2994	3014	3029	3044	3056	3069	3090	3106	3118	–	3149	3171	3191	3198	3218	3236	3252	3268	3280	3289	3303	3322
Wc+Ec	−10	−10	−10	−10	−10	−10	−10	−9	−8	−8	−7	−6	−6	−6	−7	−8	−9	−10	−11	−11	−10	−10	−10	−9	−9
fc	2959	2970	2989	3004	3024	3039	3054	3065	3077	3098	3113	3124	–	3155	3178	3199	3207	3228	3247	3263	3278	3290	3299	3312	3331
	1946						1947						1948						1949						1950

S.P.1926

to	2448	2470	2493	2513	2535	2559	2580	2599	2617	2630	2646	2665	–	2707	2722	2737	2758	2774	2790	2806	2820	2844	2864	2876	2895
Wc+Ec	−7	−7	−7	−8	−8	−8	−8	−8	−8	−8	−8	−8	−8	−8	−8	−9	−9	−9	−9	−9	−9	−8	−8	−8	−8
fc	2455	2477	2500	2521	2543	2567	2588	2607	2625	2638	2654	2673	–	2715	2730	2746	2767	2783	2799	2815	2829	2852	2872	2884	2903
	1944						1945						1946						1947						1948

S.P.1928

No Pickable Events

to				
Wc+Ec				
fc				
	1943	1944	1945	1946	1947

S.P.1961

to	3869	3851	3836	3823	3811	3798	3779	3768	3755	3737	3726	3704	–	3680	3665	3650	3638	3623	3608	3593	3577	3565	3551	3534	3523
Wc+Ec	−6	−6	−6	−6	−6	−6	−6	−5	−4	−4	−3	−2	−2	−2	−3	−4	−5	−6	−7	−7	−6	−6	−6	−5	−5
fc	3875	3857	3842	3829	3817	3804	3785	3773	3759	3741	3729	3706	–	3682	3668	3654	3643	3629	3615	3600	3583	3571	3557	3539	3528
	1930				1931				1932								1933							1934	

S.P.1958

to	3625	3610	3596	3581	3566	3553	3539	3524	3510	3497	3481	3466	–	3436	3420	3408	3395	3379	3365	3351	3336	3325	3311	3297	3283
Wc+Ec	−10	−10	−10	−10	−10	−10	−10	−9	−8	−8	−7	−6	−6	−6	−7	−8	−9	−10	−11	−11	−10	−10	−10	−9	−9
fc	3635	3620	3606	3591	3576	3563	3549	3533	3518	3505	3488	3472	–	3442	3427	3416	3404	3389	3376	3362	3346	3335	3321	3306	3292
	1930				1931				1932								1933							1934	

S.P.1955

to	3345	3331	3320	3305	3290	3277	3262	3247	3232	3219	3203	3185	–	3148	3129	3110	3093	3075	3059	3039	3021	3004	2984	2969	2949
Wc+Ec	−10	−10	−10	−10	−10	−10	−10	−10	−9	−8	−7	−6	−6	−8	−7	−8	−9	−10	−11	−11	−10	−10	−10	−9	−9
fc	3355	3341	3330	3315	3300	3287	3272	3257	3241	3227	3210	3191	–	3154	3136	3118	3102	3085	3070	3050	3031	3014	2994	2978	2958
	1930				1931				1932								1933							1934	

S.P.1954

to	3065	3040	3023	3006	2990	2970	2953				No	Pickable	Events												
Wc+Ec	−5	−6	−7	−8	−9	−10	−11																		
fc	3070	3046	3030	3014	2999	2980	2964																		
	1932				1933				1934								1935							1936	

S.P.1952

No Pickable Events

to														2241	2219	2195	2174	2152	2129	2104	2082	2067	2042	
Wc+Ec														−10	−10	−10	−10	−11	−12	−12	−13	−13	−13	
fc														2251	2229	2205	2184	2163	2140	2116	2094	2080	2055	
	1933				1934				1935								1936							1937	

S.P.1930

to	1734	1749	1766	1784	1804	1819	1840	1853	1871	1892	1907	1920	–	1956	1975	–	No	Pickable	Events						
Wc+Ec	−9	−9	−8	−8	−7	−7	−7	−7	−7	−8	−8	−8	−8	−8	−8										
fc	1743	1758	1774	1792	1811	1826	1847	1860	1878	1900	1915	1928	–	1964	1983										
	1942				1943				1944							1945							1946		

S.P.1932

to	1403	1422	1440	1459	1473	1499	1519	1534	1551	1571	1591	1608	–	1641	1660	1682		No	Pickable	Events					
Wc+Ec	−8	−8	−8	−8	−9	−9	−9	−9	−8	−8	−7	−7	−7	−7	−7	−7									
fc	1411	1430	1448	1467	1482	1508	1528	1543	1559	1579	1598	1615	–	1648	1667	1689									
	1941				1942				1943								1944							1945	

S.P. 1934

No Pickable Events

to					
Wc+Ec					
fc					
	1940	1941	1942	1943	1944

S.P.1936

to	411	429	442	462	479	494	521	538	558	574	593	611	–	642	660	677	698	712	731	749	760	779	–	–	–
Wc+Ec	−9	−9	−9	−8	−8	−8	−8	−8	−8	−8	−9	−9	−9	−9	−9	−9	−10	−10	−10	−10	−9	−9	−9	−8	−8
fc	420	438	451	470	487	502	529	546	566	583	602	620	–	651	669	687	708	722	741	759	769	788	–	–	–
	1939				1940				1941								1942							1943	

S.P.1938

to	–	54	101	125	146	163	185	204	221	241	261	282	–	318	341	355	373	395	407	429	446	464	482	500	518
Wc+Ec	+7	+7	−9	−9	−9	−9	−9	−9	−9	−8	−8	−8	−8	−8	−8	−9	−9	−9	−9	−9	−9	−10	−10	−10	−10
fc	–	47	110	134	155	172	194	213	230	249	269	290	–	326	349	364	382	404	416	438	455	474	492	510	528
	1938				1939				1940								1941							1942	

S.P.1950

to	2003	1973	1950	1929	1909	1891	1870	1848	1826	1804	1781	1759	–	1716	1690	1666	1645	1625	1604	1584	1563	1542	1520	1499	1482
Wc+Ec	−8	−8	−8	−9	−9	−9	−9	−9	−9	−10	−10	−10	−10	−10	−10	−11	−11	−12	−12	−11	−11	−10	−10	−9	−9
fc	2011	1981	1958	1938	1918	1900	1879	1857	1835	1814	1791	1769	–	1726	1700	1677	1656	1637	1616	1595	1574	1552	1530	1508	1491
	1934				1935				1936								1937							1938	

S.P. 1948

to	1599	1581	1561	1539	1519	1498	1475	1455	1434	1411	1391	1372	–	1330	1310	1289	1267	1247	1231	1210	1189	1169	1151	1128	1114
Wc+Ec	−16	−16	−16	−16	−16	−16	−16	−16	−17	−17	−18	−18	−19	−18	−18	−17	−17	−16	−16	−16	−16	−16	−16	−16	−16
fc	1615	1597	1577	1555	1535	1514	1491	1471	1451	1428	1409	1390	–	1348	1328	1306	1284	1263	1247	1226	1205	1185	1167	1144	1130
	1935				1936				1937								1938							1939	

S.P.1946

to														1036	1020	1001	982	964	944	923	–	883	867	848	830	809	793	771	752	731	712	693	670
Wc+Ec														−26	−26	−26	−25	−25	−24	−24	−23	−23	−23	−23	−23	−23	−23	−23	−22	−22	−22	−22	
fc														1062	1046	1027	1007	989	968	947	–	906	890	871	853	832	816	794	775	753	734	715	692
														1936			1937				1938				1939						1940	

S.P. 1944

to	–	–	787	763	747	721	706	688	669	649	629	610	–	569	548	524	498	485	464	446	428	410	392	375	356
Wc+Ec	−12	−12	−11	−10	−10	−9	−9	−9	−9	−9	−9	−9	−9	−9	−9	−8	−8	−8	−8	−8	−8	−9	−9	−9	−9
fc	–	–	798	773	757	730	715	697	678	658	638	619	–	578	557	532	506	493	472	454	436	419	401	384	367
			1937			1938				1939							1940							1941	

S.P. 1942

to	515	494	471	454	440	412	391	370	343	324	305	292	–	258	239	221	205	189	172	155	135	120	100	54	–
Wc+Ec	−7	−7	−7	−7	−7	−7	−7	−7	−7	−6	−6	−6	−6	−6	−6	−7	−7	−7	−7	−7	−8	−8	−8	+7	+7
fc	522	501	478	461	447	419	398	377	350	330	311	298	–	264	245	228	212	196	179	162	143	128	108	47	–
	1938				1939				1940								1941							1942	

TO ACCOMPANY RECORD No. 1967/90

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F54/B3-150

PLATE 83

TRAVERSE F

SHOT—POINTS

SOUTH—WEST 160 163 166 169 172 175 178 181 184 187 190 193 196 199 202 205 208 211 214 217 220 223 226 229 232 235 238 241 244 247 250 253 NORTH—EAST

TRAVERSE L

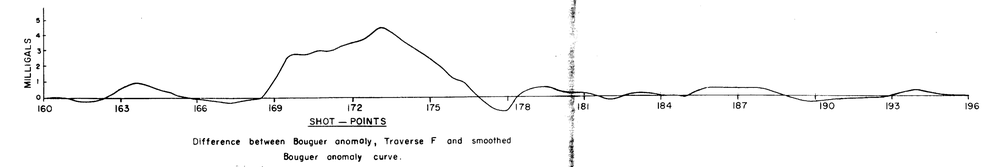
SHOT—POINTS

3096 3099 3102 3105 3108 3111 3114 3117

BOUGUER ANOMALY (MGAL) +10 +5 0 −5 −10 −15 −20 −25 −30

REFLECTION TIME (SECONDS) 0 0·5 1·0 1·5 2·0 2·5 3·0 3·5 4·0

SMOOTHED BOUGUER ANOMALY CURVE, TRAVERSE F



Difference between Bouguer anomaly, Traverse F and smoothed Bouguer anomaly curve.

LEGEND

BOUGUER ANOMALY, TRAVERSE F
Station interval 1800 ft
Station interval 600 ft

BOUGUER ANOMALY, TRAVERSE L
Station interval 1800 ft

Seismic reflection event, TRAVERSE F (not 'migrated')

REFLECTION TIME (SECONDS) 0 0·5 1·0 1·5 2·0 2·5 3·0 3·5 4·0

BOUGUER ANOMALY (MGAL) +10 +5 0 −5 −10 −15 −20 −25 −30

COMPARISON OF SEISMIC AND GRAVITY RESULTS ON TRAVERSE F AND GRAVITY RESULTS ON TRAVERSE L

HORIZONTAL SCALES
0 1 2 3 MILES
2400 0 2400 4800 7200 FEET
VERTICAL SCALES AS SHOWN

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. F54/B2-31-1

TO ACCOMPANY RECORD No. 1967/90

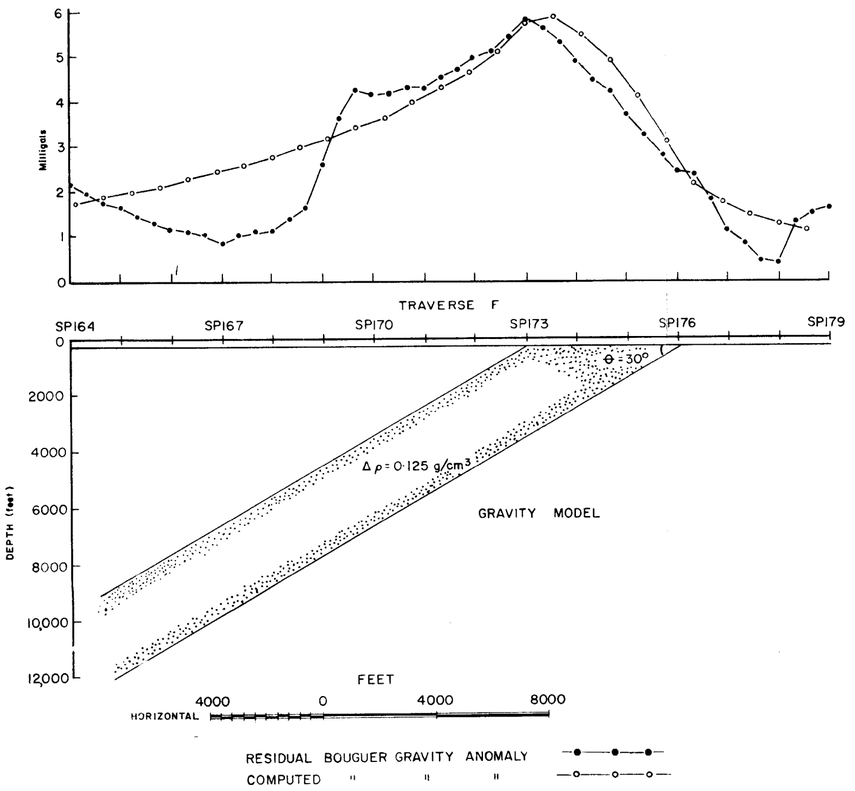


FIGURE 1. COMPARISON OF RESIDUAL AND COMPUTED BOUGUER GRAVITY ANOMALIES

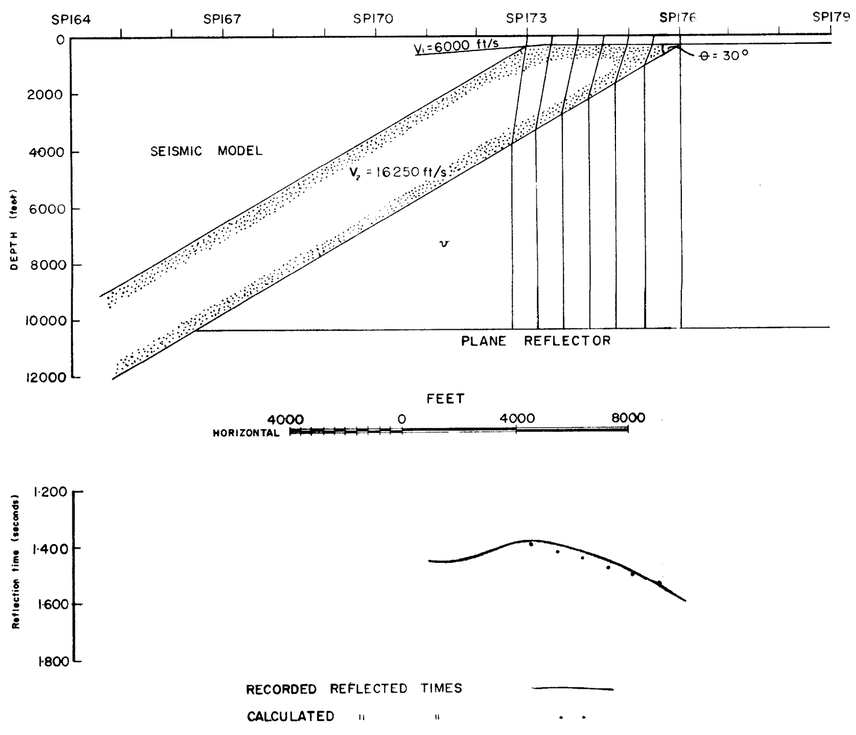


FIGURE 2. COMPARISON OF RECORDED REFLECTION TIMES AND CALCULATED REFLECTION TIMES

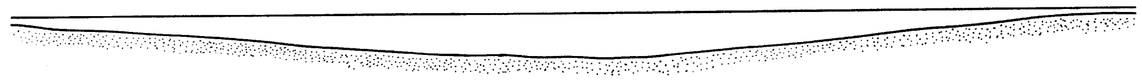


FIGURE 3a

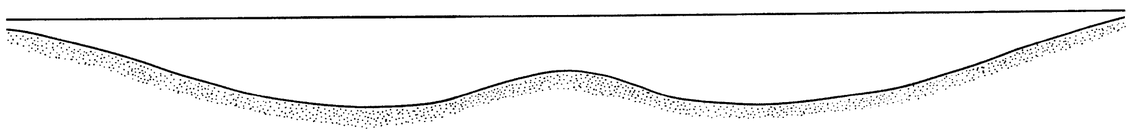


FIGURE 3b

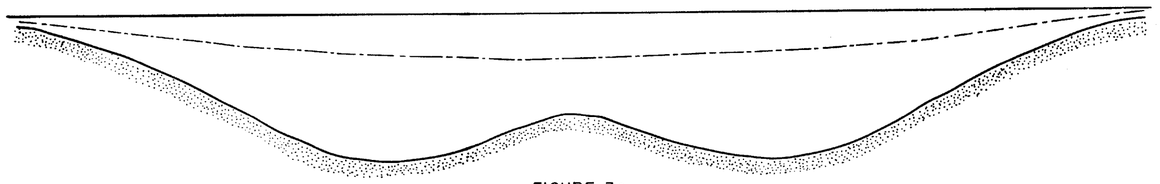


FIGURE 3c

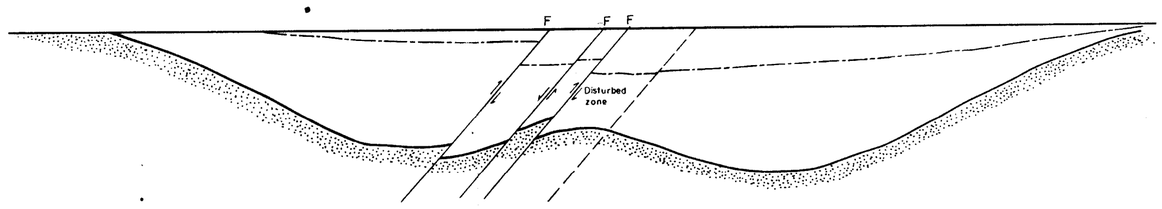


FIGURE 3d

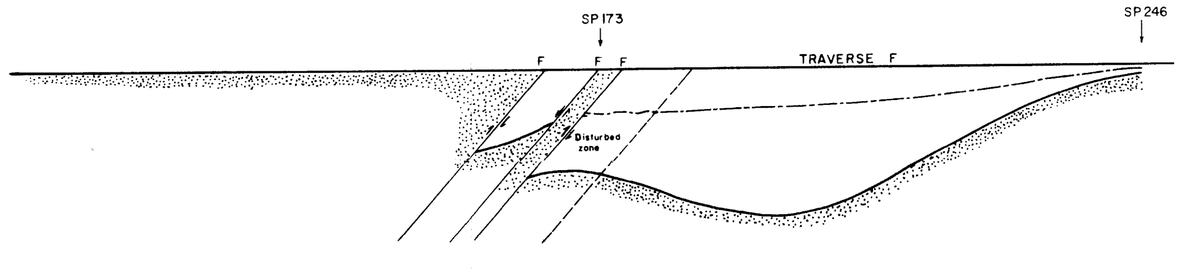


FIGURE 3e

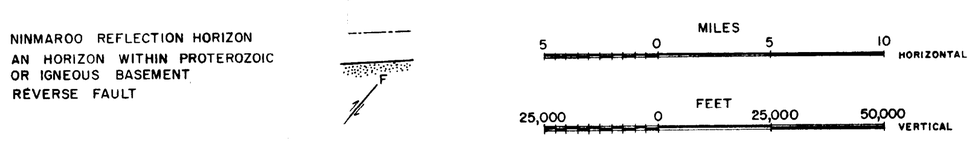


FIGURE 3 DIAGRAMMATIC REPRESENTATION OF POSSIBLE TECTONIC HISTORY OF TOKO SYNCLINE

SOUTH EAST GEORGINA BASIN
SEISMIC SURVEY 1963–1964