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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1966/144

ST GEORGE-EULO RECONNAISSANCE SEISMIC SURVEY, GREAT ARTESIAN BASIN,

QUEENSLAND 1962

by

J.S. DAVIES and K.B. LODWICK

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SUMMARY

A seismic survey was made between St George and the Queensland/South Australia border in the latter half of 1962. The results of the part of the survey over the Surat Basin, the Nebine Ridge, and the Eulo Shelf are presented in this Record.

The survey aimed at providing information on the nature and structure of the rocks underlying the Mesozoic sediments of the Great Artesian Basin, in particular across the Nebine Ridge and Eulo Shelf.

The results of the survey between St George and Bollon indicated a sedimentary section of the order of 5000 ft overlying a basement rock of either metamorphic or igneous origin. The deepest section recorded was of about 5700 ft, about 12 miles west of St George, and probably corresponds to the Boolba Trough suggested by Jenkins (1958). The sedimentary section becomes gradually thinner westward as the Nebine Ridge is approached and about 3000 ft of sediments were recorded about ten miles west of Bollon.

A reflection traverse northwards along the axis of the Boolba Trough indicated a thinning of sedimentary section of about 40 ft per mile. No structural explanation for a magnetic lineament interpreted from aeromagnetic work was found.

Velocities of over 19,000 ft/s were recorded from granitic rocks at shallow depths over the Nebine Ridge. A velocity of 19,500 ft/s was measured close to a granite outcrop at Eulo.

A thickening of the sedimentary section between the Eulo Shelf and Nebine Ridge was confirmed by refraction shooting and depths indicated that the total section (3300 ft) was not significantly greater than the depth of the water bores. No apparent development of the trough to the north or west was indicated.

1. INTRODUCTION

During the latter half of 1962, the Bureau of Mineral Resources made a seismic reconnaissance survey between St George and the Queensland/South Australia border. It was intended that the survey should link together seismic surveys done in the Surat Basin by Union Oil Development Corporation, in the Thargomindah area by Phillips Petroleum Company and L.H. Smart Oil Exploration Company Ltd, and in the Innamincka area by the Delhi-Frome-Santos group of companies.

The main purpose of the survey was to investigate the nature of the rocks beneath the Mesozoic sediments of the Great Artesian Basin, attempting to determine whether they are sedimentary, ultra basic, or igneous, and also to determine whether there are any deep troughs of sediments beneath the Mesozoic rocks.

The survey began at St George and proceeded through Bollon, Cunnamulla, Eulo, and Thargomindah towards Nappamerry (Plate 1). Reconnaissance reflection work and refraction depth probes were planned in areas where there was a likelihood that deep sedimentary troughs may exist; refraction depth probes were planned only in areas of suspected shallow basement ridges to measure the depths and velocities of the basement rocks.

This Record presents the results of the part of the survey between St George and Eulo, over the Surat Basin and the Nebine Ridge. The results of the rest of the survey, over the Eromanga Basin, are described in a separate report (Lodwick and Jones, 1964).

2. GEOLOGY AND GEOPHYSICS

Geology

Comprehensive studies of the geology of the Great Artesian Basin have been published by Whitehouse (1954) and Mott (1952). Both writers divide the southern portion of the Great Artesian Basin into two sub-basins, which are separated by the Nebine Ridge. Using the nomenclature of Mott (1952), the two sub-basins are the Surat Basin in the east and the Eromanga Basin in the west (Plate 1).

The Nebine Ridge is a shallow north-south basement ridge of granite and metamorphic rocks and is continuous laterally along the New South Wales/Queensland border with the Eulo Shelf, an area of outcropping granite between Eulo and Hungerford. North of the New South Wales/Queensland border a north-south trending depression separates the Nebine Ridge and the Eulo Shelf. This depression is situated about 20 miles east of Cunnamulla. Granite and metamorphic rocks are known respectively at shallow depths in bores drilled at Bindebango north of Bollon and at Elmina about 60 miles north-west of Bollon (Plate 2).

A study of the depths of the artesian aquifers of the water bores to the west of St George (Jenkins, 1958) suggests that there is a depression in the artesian sequence between St George and the Nebine Ridge, the amount of thickening of the sediments being of the order of 400 ft. Jenkins has called this synclinal feature the Boolba Trough.

A similar sedimentary depression mapped by Jenkins east of Surat, called the Meandarra Trough, corresponded closely with the southern extension of the Bowen Basin, where seismic evidence places the probable depth of sediments at 20,000 ft.

Geophysics

This report was prepared during the latter half of 1962 and does not include later geophysical work done by Union Oil Development Corporation, or the later gravity survey by the Bureau of Mineral Resources.

Seismic work and drilling have indicated a large trough of Triassic and Permian sediments extending beneath the artesian sequence of the Surat Basin. The axis of this trough lies to the east of St George along a line approximately between Meandarra and Toobeah. The depth of sediments is probably greatest near Meandarra, where 20,000 ft of sediments are indicated by seismic refraction work. Seismic results indicate that the sedimentary section thins to the west and is about 5000 ft near St George (Lodwick & Bigg-Wither, 1962).

Gravity observations were made in the area west of St George about 20 years ago (Shell (Qld) Development Pty Ltd, 1952). The results indicate an area of low Bouguer anomalies in the vicinity of the western side of the Nebine Ridge and the interpretation of the anomalies in terms of sedimentary section is not clear. In general the Bouguer anomalies in the Surat Basin do not bear the usual relation to thickness of sediments (i.e. positive gravity anomalies corresponding to basement uplifts and reduced thickness of sediments). However, in the Eromanga Basin there is a close correspondence between positive Bouguer anomalies and reduced sedimentary thicknesses. The Nebine Ridge lies between these two basins and without further information on the depth of basement and the possible presence of sedimentary troughs below the artesian sequence the gravity information cannot be interpreted reliably.

An aeromagnetic survey of the area west of St George was carried out by Union Oil Development Corporation. A preliminary map and interpretation supplied by Union Oil Development Corporation shows an area of slight basement depression north of the St George - Bollon road separated by an east-west magnetic lineament from an area of higher basement to the south. Depths to magnetic basement to the north of the St George - Bollon road are about 4500 ft, whereas to the south of the road (and south of the magnetic lineament), the depths are about 3500 ft below mean sea level. Two prominent magnetic anomalies, the one east of St George and the other near Boolba, indicated a depth of about 3300 ft to magnetic basement.

3. OBJECTIVES AND PROGRAMME

Objectives

The purpose of the survey was to investigate the nature of the rocks beneath the Mesozoic artesian sediments of the basin, attempting to determine whether they are sedimentary, metamorphic, or igneous, and, if large troughs of sediments are indicated, to determine the broad structural features of these troughs. The objectives for the area between St George and Eulo were as follows :

(a) Investigation of the extent of Mesozoic and Palaeozoic sedimentation in the Boolba Trough between St George and Bollon.

(b) Determine if the depression between the Nebine Ridge and the Eulo Shelf is of significant depth near Cunnamulla, and investigate its development to the north.

(c) The measurement of granite and metamorphic rock velocities on the Nebine Ridge and Eulo Shelf.

The results of the aeromagnetic work done by Union Oil Development Corporation became available after the original objectives of the seismic survey had been set, but they led to more specific aims in relation to (a) above. These were :

(1) To investigate the magnetic anomalies, one east of St George and the other near Boolba, which both indicated relatively shallow basement.

(2) To investigate the structural significance of the east-west magnetic lineament about four miles north of the South-Western Highway, between St George and Boolba.

Programme

To achieve these objectives, the following programme was carried out (traverses are shown in Plate 2) :

(1) A reconnaissance reflection traverse from St George to Bollon along the South-Western Highway, using the method of 5 miles of continuous profiling, with 5-mile gaps between (Traverse A).

(2) A refraction probe 3½ miles east of St George to measure the depth to a probably 'basement' refractor, this traverse being on the magnetic anomaly east of St George (Traverse B).

(3) A short reflection traverse east-west across the magnetic anomaly east of St George (Traverse N).

(4) A refraction probe near Boolba to measure the depth to a probable 'basement' refractor on the second of the magnetic anomalies (Traverse D).

(5) A reflection traverse in a north-south direction across the magnetic lineament north of the South-Western Highway (Traverse C).

(6) A refraction probe to measure the velocity of the granite reported at shallow depth (870 ft below sea level) in a group of bores near Bindebango (Traverse E).

(7) A refraction probe to measure the velocity of metamorphic rocks reported at shallow depth (390 ft below sea level) in bores 50 miles north-west of Bollon, near Elmina (Traverse F).

(8) A refraction spread on the granite outcrop near Eulo to measure the velocity of the granite (Traverse I).

(9) A refraction probe at Coongoola, approximately 30 miles north-east of Cunnamulla, to measure the depth to a probable 'basement' refractor (Traverse G).

(10) A reflection traverse in an east-west direction through Coongoola (Traverse H).

4. DISCUSSION OF WORK

The staff employed to carry out the survey and the equipment used are listed in Appendix A.

Statistics of the surveying, drilling, and recording techniques are presented in Appendix B; a more detailed statistical summary of the shot-hole drilling is given in Appendix C.

In the St George–Bollon area, drilling conditions were good and formations of clay, sand, sandstone, and shale were penetrated. At a few places, gravel beds were penetrated but these presented little difficulty. The fluid drilling technique was used throughout the survey except for a few shot-holes drilled early in the survey with augers. In the Coongoola area, north of Cunnamulla, a hard band of shale was encountered at about 100 ft, which slowed the penetration rate.

The weathered layer was generally deep, making it necessary to drill holes as deep as 220 ft to obtain the best records. The weathering depths sometimes varied erratically and ranged over the survey area from 80 to 170 ft. In the St George–Bollon area, velocities of the weathered layer ranged between 2000 and 4000 ft/s and for the sub-weathered layer from 6000 to 9000 ft/s. In the Coongoola area weathering velocities remained about the same and the sub-weathered layer velocities ranged between 8000 and 10,000 ft/s.

The simplified logs of shot-holes, surface elevations, depths of weathering, and sub-weathering velocities are shown on the reflection cross-sections for each traverse (Plates 3 - 6).

The quality of the best reflections recorded during the survey was only fair. In some places, at the western end of Traverse A, on Traverses B and N near St George, and on Traverse H near Coongoola, reflection quality was poor. Reflection quality was sufficiently good, however, to correlate several reflections from record to record on the parts of the traverses that were continuously shot. Correlation, even within the same energy band, between the separated parts of Traverses A and C is not considered accurate.

The results of the reflection work have been plotted in the form of reflection correlation cross-sections derived from corrected record cross-sections. The record cross-sections were prepared from wriggly-line plus variable-density records produced by an SIE TRO-6 camera. The cross-sections are plotted in depth on a natural scale and the reflection times are indicated. The results along Traverses A and C are shown in Plates 3 and 4 respectively, the results along traverses B, N, and D in Plate 5, and the results along traverses G and H in Plate 6. The results of reflection Traverse N shot in 1961 (Lodwick & Bigg-Wither, 1962) are shown in Plate 3 to facilitate reference to the reconnaissance reflection traverse from Goondiwindi to St George.

Reflection times were converted to depths from the results of a $t : \Delta t$ analysis of reflections in the Goondiwindi area in 1961 (Lodwick & Bigg-Wither, 1962); the velocity/time and time/depth curves are shown in Plate 13. Towards the end of the St George–Eulo survey, a $t : \Delta t$ analysis of reflections was made for parts of Traverse A near Boolba and Traverse D. The velocity/time and time/depth relations resulting from this analysis are shown in Plate 14. The velocity/time and time/depth curves obtained from the $t : \Delta t$ analyses in the two areas are similar. At a time of 1100 milliseconds, where the divergence is greatest, depths of 5050 ft and 5200 ft are obtained from the Goondiwindi and Boolba time/depth relationships respectively (Plates 13 and 14).

Refraction records were of good quality on Traverses B, E, F, G, and I and this enabled reliable measurements of refractor velocities and delay times to be made. The results of these traverses are shown in Plates 7, 9, 10, 11, and 12 respectively. On Traverse D (Plate 8), however, the refracted energy arrival times are difficult to interpret and reliable results were not obtained (Section 5).

5. INTERPRETATION

Seismic reflection surveys that have been made in the main sedimentary trough of the Surat Basin, which runs through Meandarra to Toobeah, have generally recorded a strong characteristic reflection that has been designated the 'L' horizon. This horizon has been shown to correlate with the upper part of the Permian section. In the survey conducted by the BMR in the southern Surat Basin during 1961, Lodwick and Bigg-Wither (1962) were able to recognise this reflection in the central part of the survey area, between Toobeah and Goondiwindi, and considered that it was probably continuous to Traverse N (1961) to the west of St George (Lodwick & Bigg-Wither, 1962). At SP 366 on Traverse N (1961) the reflection correlated with the 'L' horizon is at a time of 1.095 seconds or 5000 ft below the 600-ft datum. However, this correlation could only be considered as reliable as far as 4 miles east of Talwood. Further west, the correlation relied on character correlation across large unshot sections of the traverse, and as the records were often of poor quality, the correlation was doubtful.

U-K-A St George No. 1 was subsequently drilled in 1963, at a point 3½ miles north of Traverse N (1961) and encountered metamorphic basement rocks at a depth of 4500 ft (below the 600-ft datum) without penetrating any Permian section. This reflecting horizon on Traverse N (1961) is therefore probably associated with the top of the metamorphic basement rocks.

To the east of St George, at the intersection of Traverses B and N, this probable basement reflection is recorded at a depth of 5450 ft. Along Traverse N (Plate 5) it shows a slight westerly dip and on Traverse B (Plate 5) it is fairly flat in the northern part, but dips markedly to the south, south of SP 751. A refraction probe was also shot on Traverse B, and a high velocity refractor (velocity 20,140 ft/s) was recorded from a calculated depth of 4800 ft (Plate 7). This refractor can almost certainly be correlated with a metamorphic or igneous basement rock, probably metamorphic in view of the results of St George No. 1. The difference in calculated depths of this refractor and the supposed 'basement' reflection can be partly explained by the different average vertical velocities used in each case. A value of 8660 ft/s, derived by matching profiles to obtain the offset distance, has been used in the refraction calculation, whereas a value of 9400 ft/s, derived from the t : Δt analysis, was used in the reflection calculation. After adjustment for this discrepancy, the depth values agree to within 300 ft, which is well within the error limits of the refraction method of depth determination.

Both reflection and refraction shooting were also done on Traverse D, near Boolba. A reflection which probably correlates with the 'basement' reflection on Traverse N (1961) is at a depth of 5100 ft on this traverse. The refraction probe was difficult to compute as there was no correspondence between the direct and reverse profiles (Plate 8). An approximate velocity of 18,600 ft/s was obtained for the refractor and its depth calculated to be 4700 ft. This refractor can also be interpreted as metamorphic basement. The discrepancy in its depth as compared with that of the inferred 'basement' reflection can again be explained by the different average velocities used and the inaccuracy of the refraction method. There is evidence of minor faulting in the basement as two probable diffractions diverge from the basement reflection at shot-points 812 and 813. This faulting may account for the poor correlation between the direct and reverse refraction shots.

There is therefore a reasonable basis for interpreting a particular reflecting horizon, occurring at about 5000 + ft in the St George area as representing the metamorphic basement. Correlation of this horizon along and between traverses was not always possible, but where doubt exists, the deepest of the reliable reflections has been assumed to represent the basement horizon.

The general basement relief, as shown by the probable 'basement' reflection along Traverses A and N, is a gentle deepening of the basement from 3300 ft (below the 600-ft datum) at SP 516 at the western end, to 5700 ft at SP 716, and then a rise to 5000 ft on Traverse N (1961) before beginning to deepen again. There is thus a basement 'high' in the vicinity of St George with a relief of about 700 ft. The depression to the west of St George does not correspond closely to the Boolba Trough, being about 18 miles east of Boolba. There are minor interruptions to this general trend, including some faults, which occur at SP 638, SP 707, and SP 351.

The reflections recorded from the section above the basement cannot in general be correlated across the unshot portions of Traverse A. They do not exhibit any marked unconformity with the basement horizon, but there are some minor disconformities.

Strong reflections with steep easterly dips were recorded at depths of about 6000 to 8000 and at 13,000 to 15,000 ft on Traverse N (1961), and also from 4500 to 8000 ft on Traverse A between shot-points 607 and 613 (Plate 3). The significance of these reflections is not known. Their strength and persistence, however, suggests that the basement rock is stratified at certain places and may, at least in part, be metamorphic rock rather than igneous. Weak, almost horizontal, reflections were recorded from below the supposed 'basement' reflection beneath Traverse A, between shot-points 708 and 715.

The attitude of the probable 'basement' reflection and also the reflections above it, along Traverse C, indicates a gradual thinning of the sedimentary section towards the north, from 5500 ft near Traverse A to 5100 ft at the northern end of Traverse C. No apparent structural expression of the magnetic lineament, interpreted from aeromagnetic data was found in the reflection cross-section.

On Traverse E about 16 miles north of Bollon a refraction depth probe (Plate 9) recorded a velocity of 19,170 ft/s at a depth of 1900 ft below datum (600 ft above M.S.L.). In bores nearby, granite was reported at depths between 1470 and 1870 ft below datum. The velocity and the depth of the refractor are such that the refractor almost certainly represents the granite.

A similar refraction depth probe on Traverse F recorded a velocity of 19,220 ft/s at a depth of 1600 ft below datum. Metamorphic rocks were reported in a nearby bore at a depth about 1000 ft below datum. The velocity of the refractor recorded is of the order expected for some types of metamorphic rocks. Considering, however, the depth of the refractor and the fact that a velocity of 19,170 ft/s was recorded over granite on Traverse E, it is possible that the refractor recorded on Traverse F represents a granitic rock below the metamorphic rocks encountered in the nearby bore.

The results of Traverses E and F and the western end of Traverse A do not show any indication of the development of a trough of sediments associated with a Bouguer anomaly 'low' that trends north-north-east (Shell (Qld) Development Pty Ltd, 1952). The Bouguer anomaly 'low' is probably the expression of the shallow granitic basement rather than the development of a sedimentary trough.

At Coongoola a refraction depth probe was shot on Traverse G (Plate 11). A velocity of 19,000 ft/s was recorded at a depth of about 3300 ft and the profile indicates a dip to the south. The velocity is high enough to suggest that the refractor represents either igneous or metamorphic basement. A poor to fair quality horizontal reflection was recorded at a depth of 2700 ft on four shot-points in the middle of

Traverse G (Plate 6). Whitehouse (1954) illustrated from bore information a thickening of the artesian sediments in the Coongoola area between the Nebine Ridge and the Eulo Shelf. The refraction and reflection results on Traverse G indicate that the depth of sedimentation is not significantly greater than the depth of the water bores, and there is no suggestion of a significant increase in section to the north.

Reflections were recorded along Traverse H (at right angles to Traverse G) to a depth of about 2800 ft. The reflection correlation cross-section (Plate 6), apart from a fault beneath SP 979, indicates an almost horizontal attitude of the sediments. There is no suggestion of a development of a deeper sedimentary trough to the west.

Traverse I was shot as a refraction depth probe to measure the velocity of granite that crops out near Eulo. The inaccessability of the granite outcrop prevented the traverse being surveyed over it, so the traverse was located more conveniently along a road about a mile west and about four miles south-west of Eulo. A velocity of 19,500 ft/s was recorded at a depth of about 1000 ft below datum (Plate 3). Considering the velocity, the proximity to the granite outcrop, and the fact that numerous granite outcrops are known between Eulo and Hungerford it is certain that the velocity of the granite was measured.

6. CONCLUSIONS

The following conclusions may be drawn from the results of the survey :

(a) The quality of reflections in this area ranges from poor to fair and it is not generally possible to correlate horizons between traverses.

(b) High velocity refractors were recorded at St George and Boolba at a depth of the same order as the metamorphic basement encountered in St George No. 1. The deepest of the reliable reflections is associated with these refractors and can reasonably be interpreted as basement along the traverses between St George and Bollon.

(c) A depression exists in the basement about 12 miles west of St George, where the maximum thickness of sedimentary section is 5700 ft. This depression is probably the equivalent of the Boolba Trough, although the deepest part is about 18 miles east of Boolba. A north-south traverse in this depression indicated a northward thinning of about 40 ft per mile.

(d) The depth of the basement gradually decreases westward towards the Nebine Ridge and is about 3000 ft ten miles west of Bollon.

(e) Velocities measured for granite at Eulo and Bindebango were 19,500 ft/s and 19,200 ft/s. At Elmina, where metamorphics are reported at shallow depth, the velocity measured was 19,200 ft/s but because the calculated depth was significantly more than the depth to the metamorphics, it is thought that this may also represent a granite velocity.

(f) There is a depth of sediments of 3300 ft at Coongoola, but there is no indication that this depression between the Nebine Ridge and Eulo Shelf develops significantly to the north and west.

(g) There is no suggestion of substantial basement 'highs' east of St George and at Boolba as interpreted from magnetic anomalies, nor is there any indication of structure associated with the east-west magnetic lineament between St George and Boolba.

7. REFERENCES

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LODWICK, K.B. and BIGG-WITHER, A.L. 1962 Southern Surat Basin, seismic survey 1961. Bur. Min. Resour. Aust. Rec. 1962/183.

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APPENDIX A

Staff and equipment

Staff

Party leader	:	K. B. Lodwick
Geophysicists	:	J. S. Davies, P. Jones
Surveyors	:	W. Lamond (Dept of Interior)
Chainman	:	P. Pullinen (Dept of Interior)
Clerk	:	W. Rossendell
Observer	:	R. Krege
Junior observer	:	G. Jennings
Draftsman	:	P. Kersulis
Shooter	:	J. Ryman
Toolpusher	:	B. F. Findlay
Drillers	:	R. Larter, A. Zoska
Mechanics	:	T. Buckley, B. Gunn
Field-hands	:	12 to 15 including cook and cook's offsider.

Equipment

Seismic amplifiers	:	Texas Instruments 8000 (Explorer)
Seismic oscillograph	:	SIE TRO-6
Magnetic recorder	:	Electro Tech. DS 7
Geophones	:	(a) 450 Electro Tech 20-c/s in groups of 6 at 22-ft intervals
		(b) 80 T.I.C. 6-c/s
Drills	:	2 Mayhew 1000, 1 Failing 750, 1 Carey
Cables	:	Portable vector 1500 and 2000 ft
Transceivers	:	S.I.E. GT 100D (3) and Traeger 51 MA
Vehicles	:	4 Land Rovers 2 International 4 x 4, 1-ton trucks 4 International 4 x 4, 3-ton trucks 5 Bedford 4 x 4, 5-ton trucks 1 Commer 4 x 4, 3-ton truck

APPENDIX B

Table of operations

Sedimentary basin	:	Surat and Eromanga Basins
Area	:	St George to Eulo
Camp sites	:	St George (temporary accommodation at Bollon and Cunnamulla)
Established camp	:	27.7.62
Surveying commenced	:	27.7.62
Drilling commenced	:	30.7.62
Shooting commenced	:	30.7.62
Miles surveyed	:	$84\frac{2}{3}$ miles
Topographic survey control	:	Main road, railroad bench-marks and military maps
Total footage	:	32780 ft
Explosives used	:	10292 lbs
Datum level for corrections	:	600 ft above M.S.L.
Weathering velocities	:	2000 - 4000 ft/s
Sub-weathering velocities	:	5000 - 9000ft/s
Source of velocity distribution	:	t:Δt analysis (Lodwick & Bigg-Wither, 1962) t:Δt analysis near Boolba and velocity profile on Traverse C

Reflection shooting data

Shot-point interval	:	1800 ft
Geophone group	:	Six in line of traverse at 22-ft spacing
Geophone group interval	:	1800 ft
Holes shot	:	186
Miles traversed	:	$47\frac{1}{3}$ miles
Common shooting depths	:	170 ft
Usual recording filter	:	K22-K125
Usual playback filter	:	M22-K72 and K22-K72
Common charge sized	:	10 - 30 lbs
Weathering corrections	:	Centre or end traces using up-hole times

Refraction shooting data

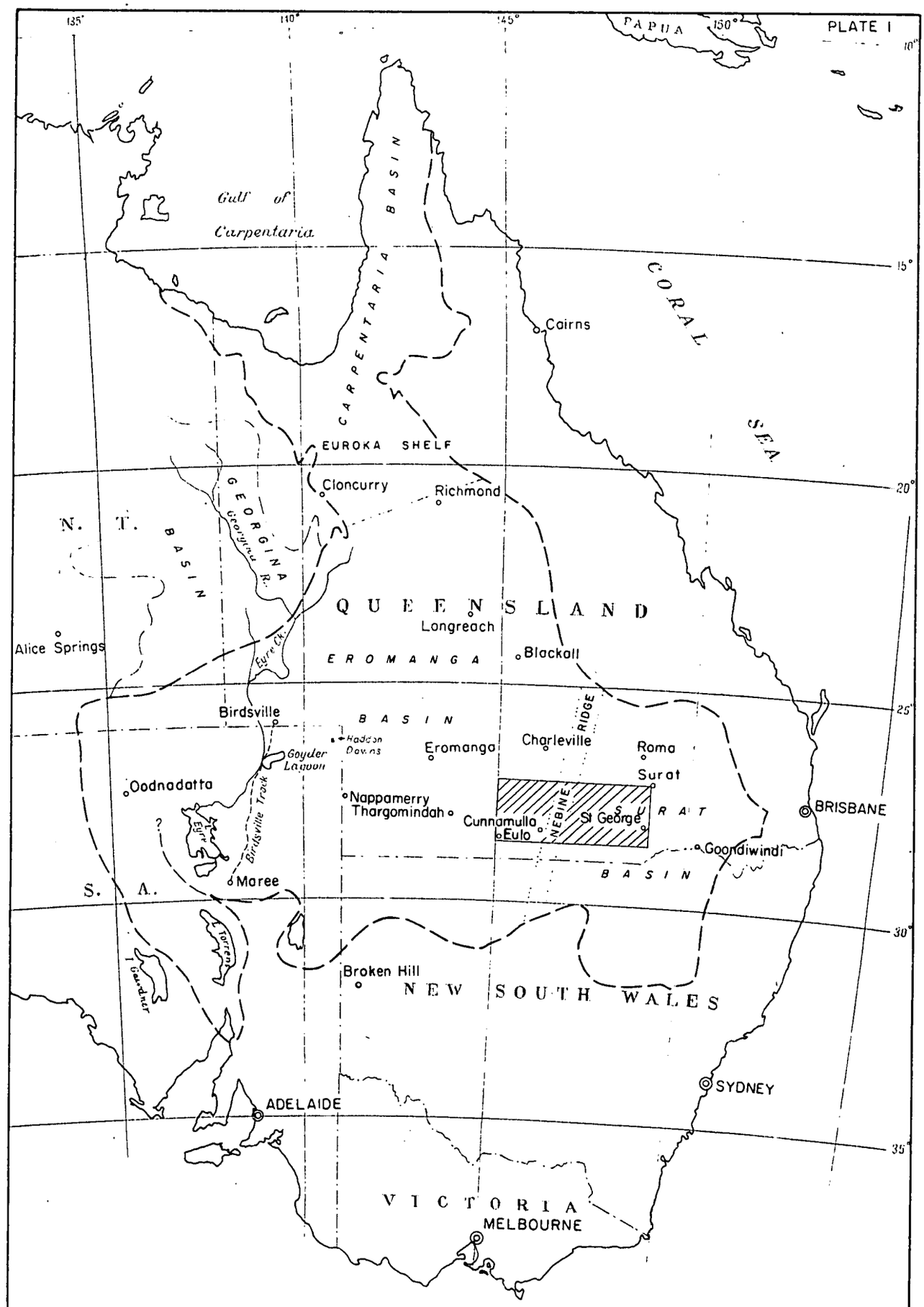
Geophone group	:	1 six cycle
Geophone group interval	:	300 ft
Holes shot	:	22
Usual recording filters	:	0 - 72
Number of refraction traverses	:	Six
Charge sizes	:	50 - 150 lbs
Maximum shot-to-geophone distance	:	$4\frac{1}{3}$ miles
Weathering control	:	From reflection work

APPENDIX C

Drilling statistics

	Mayhew	Carey	Failing
Total footage drilled	17,075	3,339	12,367
Total No. of holes drilled	106	19	83
Average depth of holes (feet)	161	178	149
Deepest hole drilled (feet)	305	207	207
Travelling time and rigging up (hours)	111¼	16½	95½
Time lost waiting on water (hours)	4	2½	2½
Time lost repairs to drill (hours)	19	4	18¾
Time lost because of rain (hours)	4		4
Time lost repairs to rig engine			
Time lost waiting on surveyors		Nil	
Time lost public holidays			
Drilling time (hours)	177	64½	194½
No. of shifts worked	34	10	38
Maintenance to drill (hours)	40¼	9	18
Bentonite used (bags)	3	-	17
Rate of penetration (feet/hour)	89.7	51.2	61.2

PLATE I



ST GEORGE / EULO SEISMIC SURVEY 1962

LOCALITY MAP

LEGEND

Boundary of Great Artesian Basin

Area covered by survey

SCALE IN MILES

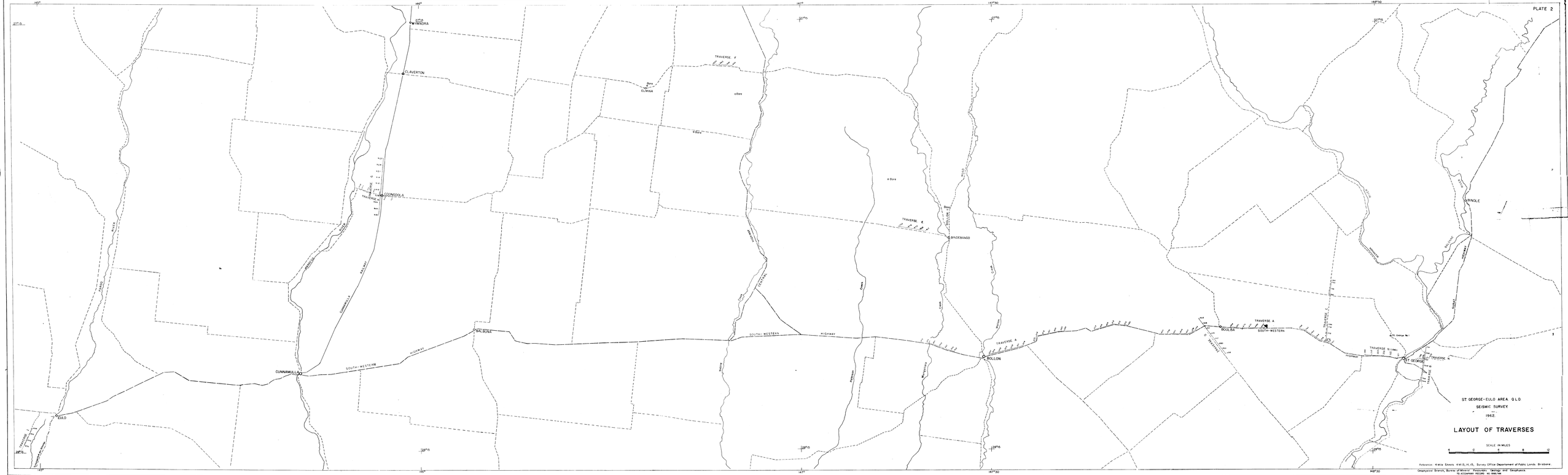
100 0 100 200 300

(Based on G20-24)

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G55/B 3-38

TO ACCOMPANY RECORD NO. 1966/144

PLATE 2



G50/63-26

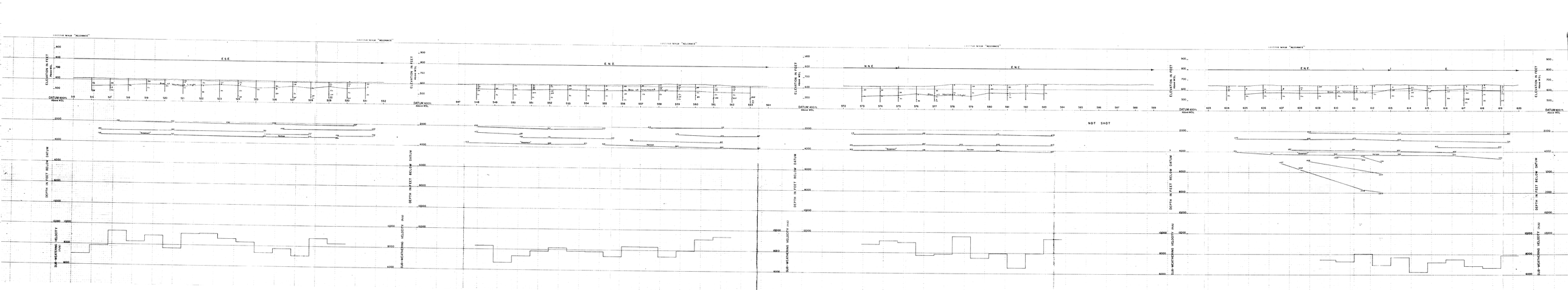
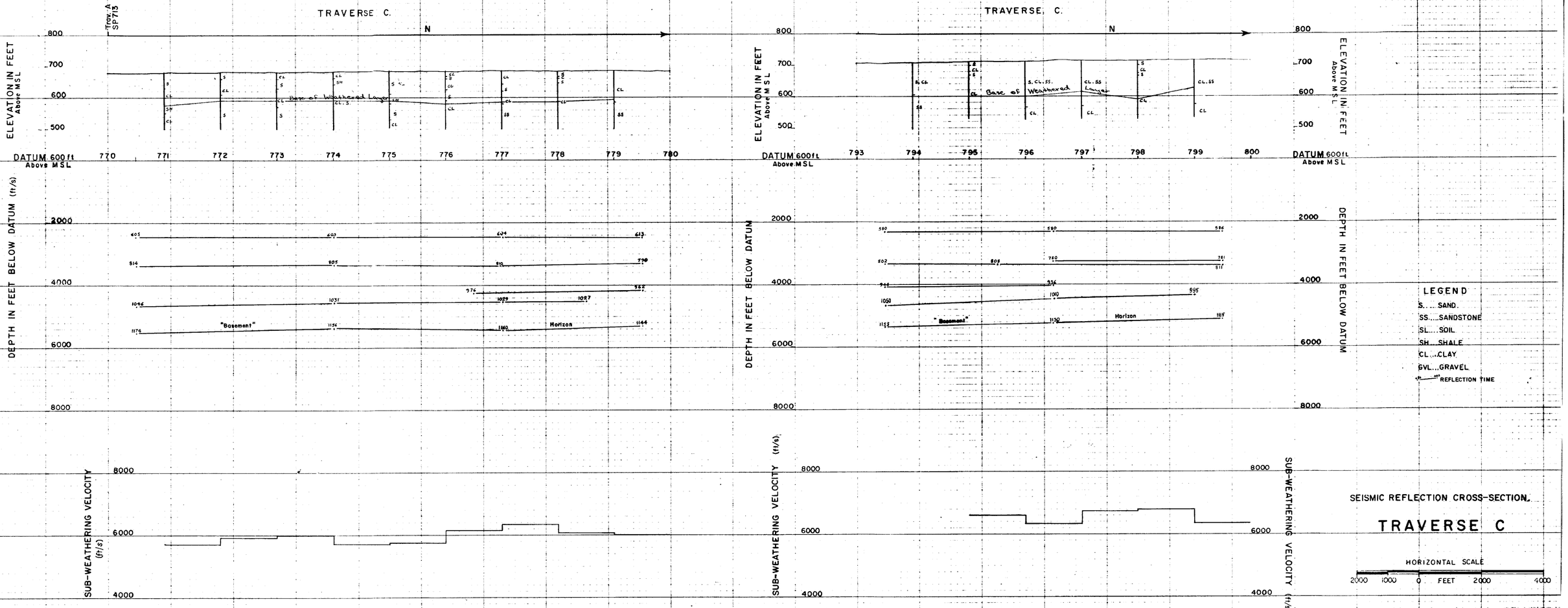

SEISMIC MAP "ALLIANCE"
ESE
ELEVATION IN FEET Above MSL
DATUM 4000 ft Above MSL
DEPTH IN FEET BELOW DATUM
SUB-WEATHERING VELOCITY (fps)
SEISMIC MAP "ALLIANCE"
ENE
ELEVATION IN FEET Above MSL
DATUM 4000 ft Above MSL
DEPTH IN FEET BELOW DATUM
SUB-WEATHERING VELOCITY (fps)
SEISMIC MAP "ALLIANCE"
NNE
ENE
ELEVATION IN FEET Above MSL
DATUM 4000 ft Above MSL
DEPTH IN FEET BELOW DATUM
SUB-WEATHERING VELOCITY (fps)
NOT SHOT
SEISMIC MAP "ALLIANCE"
ENE
E
ELEVATION IN FEET Above MSL
DATUM 4000 ft Above MSL
DEPTH IN FEET BELOW DATUM
SUB-WEATHERING VELOCITY (fps)

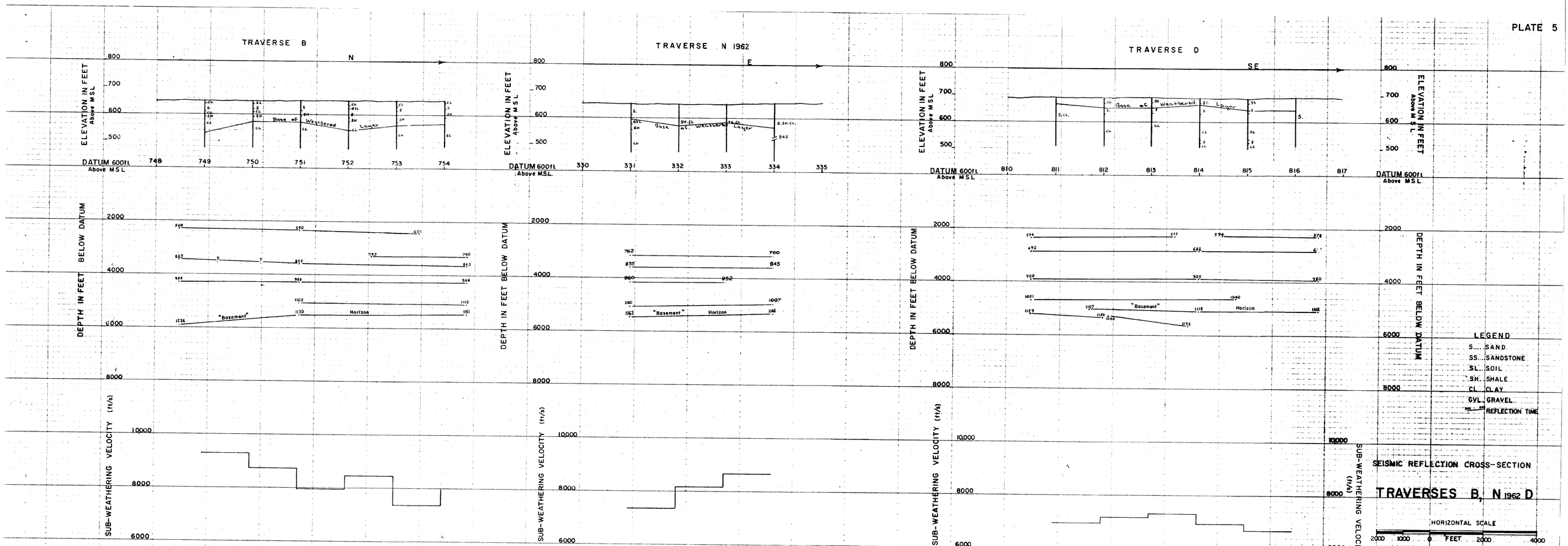

PLATE 5
TRAVERSE A
TRAVERSE N (1961)
ELEVATION IN FEET
DEPTH IN FEET BELOW DATUM
SUB-WEATHERING VELOCITY (ft/s)
LEGEND
S...... SAND
SS... SANDSTONE
SL.... SOIL
SH.... SHALE
CL.... CLAY
GVL .... GRAVEL
REFLECTION TIME
SEISMIC REFLECTION CROSS-SECTION
TRAVERSES A AND N (1961)
HORIZONTAL SCALE
2000 0 FEET 2000 4000
Geophysical Branch, Bureau of Mineral Resources Geology and Geophysics. G55/B3-27
TO ACCOMPANY RECORD NO. 1966/144

PLATE 4



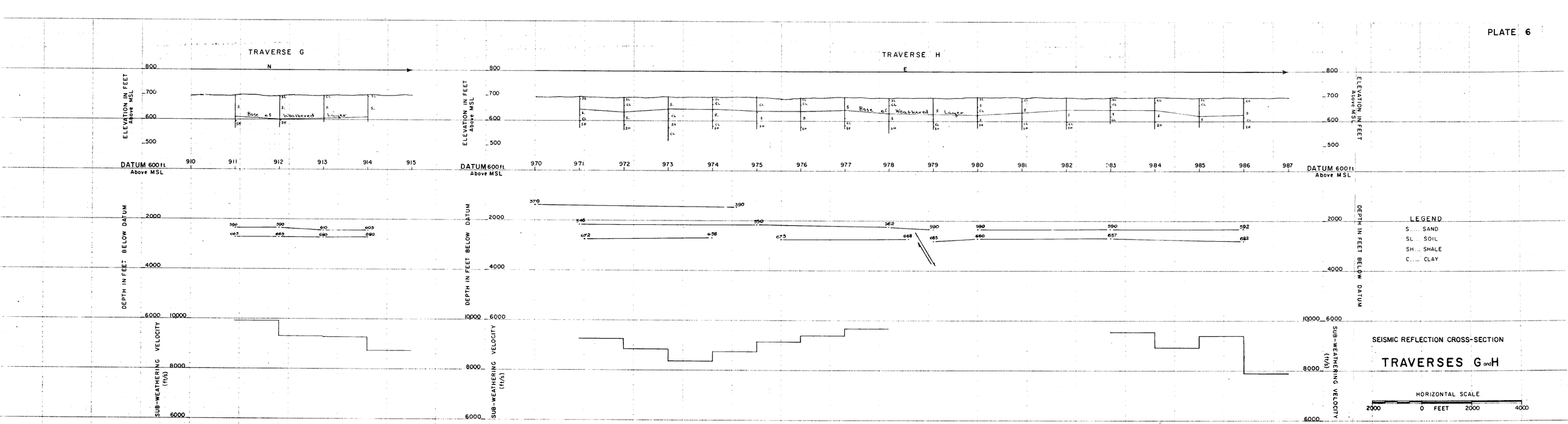
Geophysical Branch, Bureau of Mineral Resources Geology and Geophysics G55/B3-28
TO ACCOMPANY RECORD NO. 1966/144

PLATE 5



Geophysical Branch Bureau of Mineral Resources Geology and Geophysics G55/B3-29
TO ACCOMPANY RECORD NO. 1966/144

PLATE 6



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G55/B3-30
TO ACCOMPANY RECORD NO. 1966/144

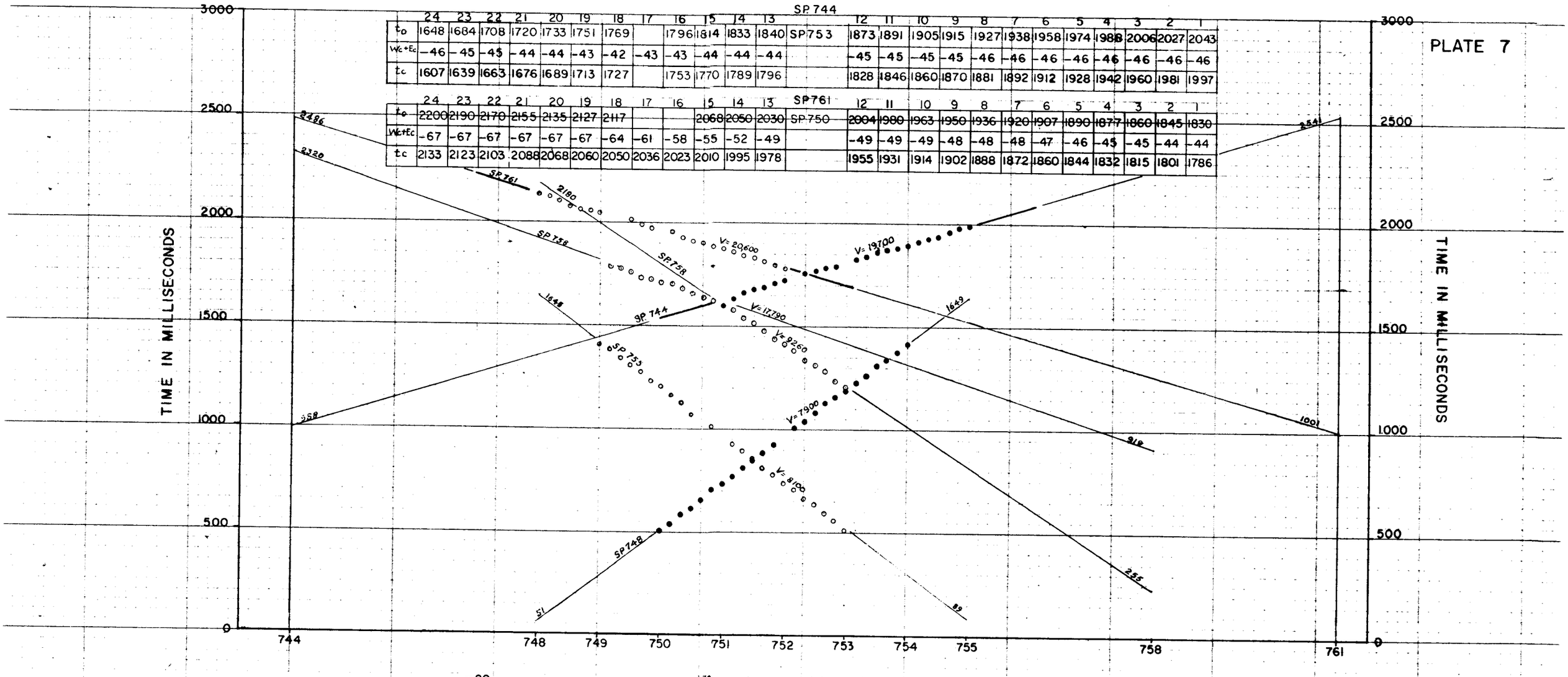
PLATE 7

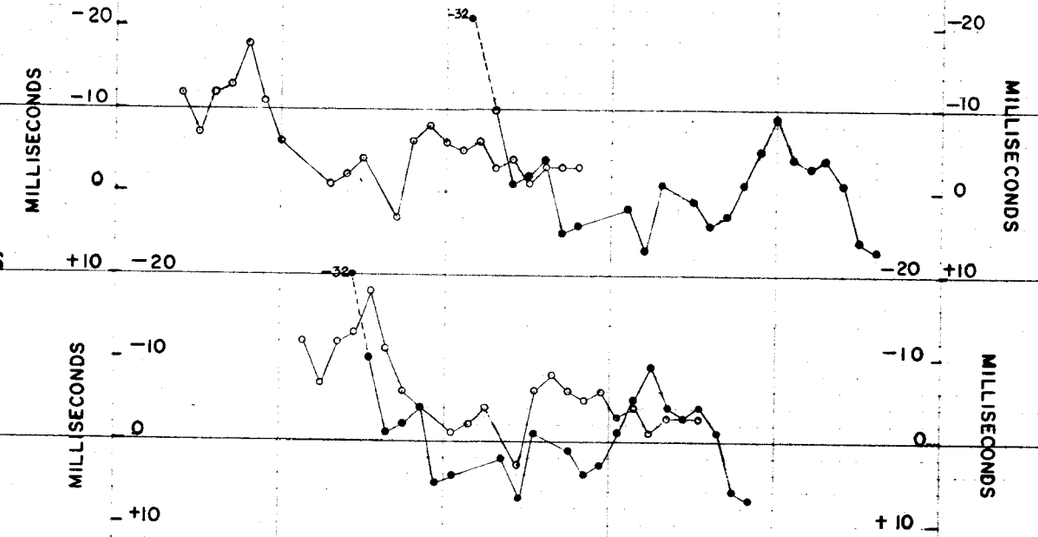
SP 744

	24	23	22	21	20	19	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1
t_o	1648	1684	1708	1720	1733	1751	1769		1796	1814	1833	1840	SP 753	1873	1891	1905	1915	1927	1938	1958	1974	1988	2006	2027	2043
W_c+E_c	-46	-45	-45	-44	-44	-43	-42	-43	-43	-44	-44	-44		-45	-45	-45	-45	-46	-46	-46	-46	-46	-46	-46	-46
t_c	1607	1639	1663	1676	1689	1713	1727		1753	1770	1789	1796		1828	1846	1860	1870	1881	1892	1912	1928	1942	1960	1981	1997

SP 761

	24	23	22	21	20	19	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1
t_o	2200	2190	2170	2155	2135	2127	2117			2068	2050	2030	SP 750	2004	1980	1963	1950	1936	1920	1907	1890	1877	1860	1845	1830
W_c+E_c	-67	-67	-67	-67	-67	-67	-64	-61	-58	-55	-52	-49		-49	-49	-49	-48	-48	-48	-47	-46	-45	-45	-44	-44
t_c	2133	2123	2103	2088	2068	2060	2050	2036	2023	2010	1995	1978		1955	1931	1914	1902	1888	1872	1860	1844	1832	1815	1801	1786





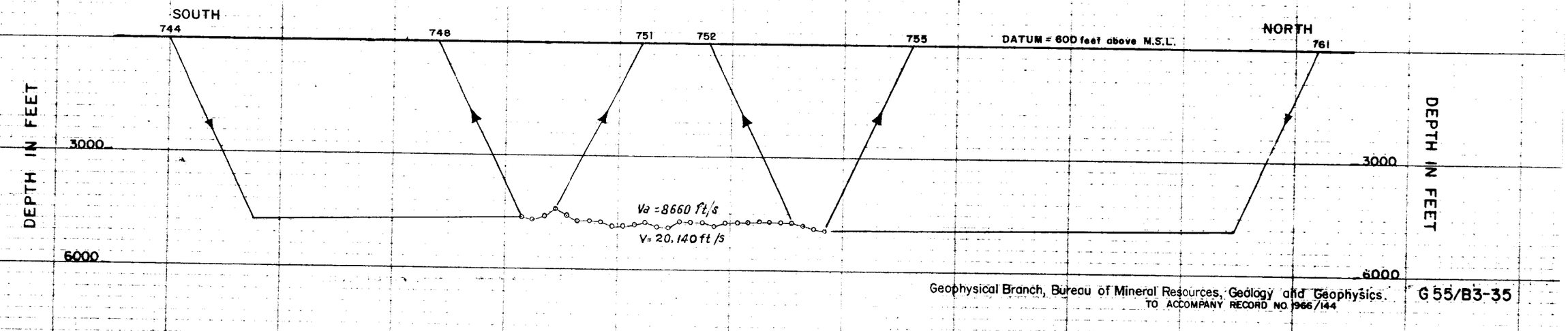
RELATIVE INTERCEPT TIMES

SEISMIC REFRACTION RESULTS

TRAVERSE B

HORIZONTAL SCALE

3000 2000 1000 0 FEET 3000 6000



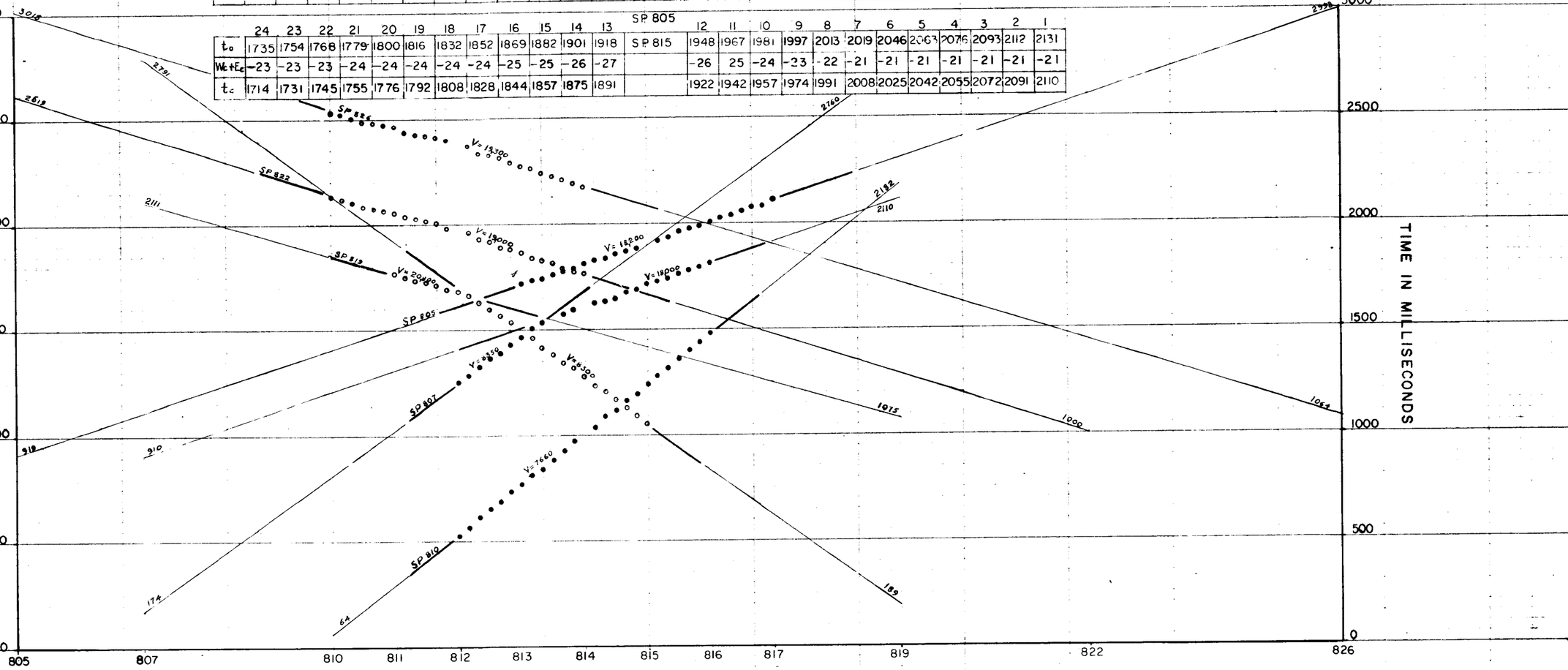
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.
TO ACCOMPANY RECORD NO. 1966/144

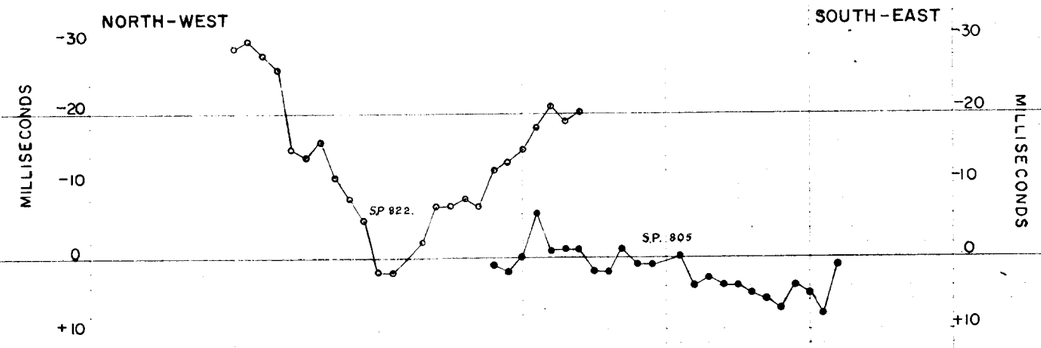
G 55/B3-35

PLATE 8

	24	23	22	21	20	19	18	17	16	15	14	13	SP 822	12	11	10	9	8	7	6	5	4	3	2	1
t_p	2158	2141	2127	2113	2105	2093	2075	2063	2050	2037	2028	2012	SP 812	1976	1955	1939	1922	1907	1885	1868	1850	1832	1813	1799	1782
W_E+E_c	-24	-24	-24	-24	-24	-24	-24	-24	-24	-24	-24	-24		-24	-24	-24	-24	-24	-24	-24	-24	-25	-25	-25	25
t_c	2134	2117	2103	2089	2084	2069	2051	2039	2026	2013	2004	1988		1952	1931	1915	1898	1883	1861	1844	1826	1807	1788	1774	1757

	24	23	22	21	20	19	18	17	16	15	14	13	SP 805	12	11	10	9	8	7	6	5	4	3	2	1
t_o	1735	1754	1768	1779	1800	1816	1832	1852	1869	1882	1901	1918	SP 815	1948	1967	1981	1997	2013	2019	2046	2063	2076	2093	2112	2131
W_E+E_c	-23	-23	-23	-24	-24	-24	-24	-24	-25	-25	-26	-27		-26	25	-24	-23	-22	-21	-21	-21	-21	-21	-21	-21
t_c	1714	1731	1745	1755	1776	1792	1808	1828	1844	1857	1875	1891		1922	1942	1957	1974	1991	2008	2025	2042	2055	2072	2091	2110





RELATIVE INTERCEPT TIMES

PROFILES DO NOT MATCH. (see fault Plate 5)

True Velocity assuming Va= 8660 ft/s and pairing Shot-points 805 and 822 = 18,580 ft/s depth= 4720 ft below datum(600 ft above M.S.L)

SEISMIC REFRACTION RESULTS

TRAVERSE D

HORIZONTAL SCALE

3000 2000 1000 0 FEET 3000 6000

Geophysical Branch, Bureau of Mineral Resources Geology and Geophysics G55/B3-31
TO ACCOMPANY RECORD NO. 1968/144

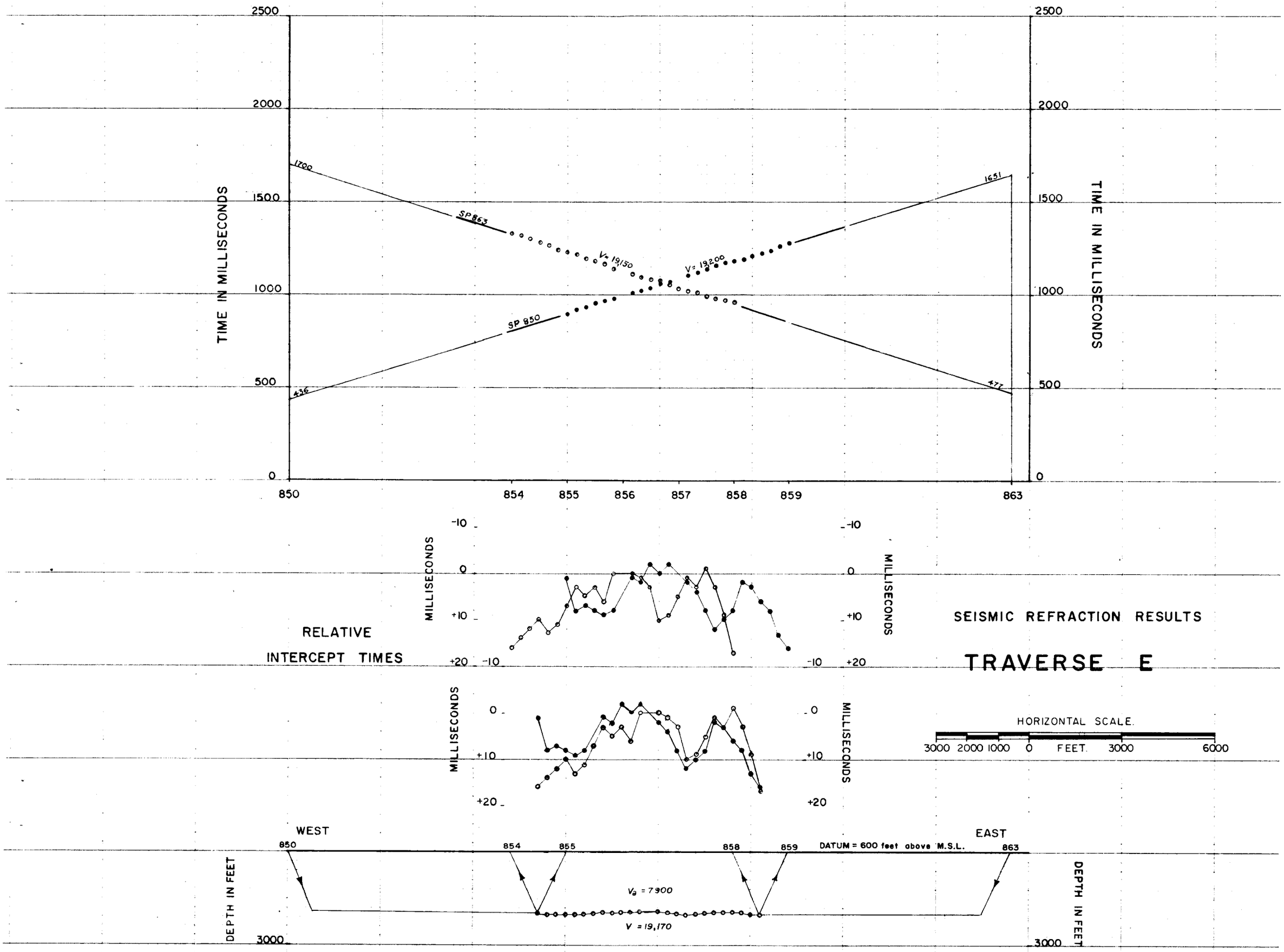
PLATE 9

SP 857

	24	23	22	21	20	19	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1
t_o	941	963	978	993	1010	1024		1048	1064	1078	1093	1107		1141	1159	1179	1199	1212	1225	1235	1251	1270	1287	1307	1326
W_t+E_c	-42	-42	-42	-42	-42	-42	-41	-41	-41	-41	-41	-41		-41	-41	-41	-41	-41	-42	-42	-42	-42	-42	-42	-42
t_c	899	921	936	952	969	983		1007	1023	1037	1052	1066		1100	1118	1137	1157	1170	1183	1193	1209	1228	1245	1265	1284

SP 863

	24	23	22	21	20	19	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1
t_o	1371	1353	1336	1319	1306	1289	1269	1250	1237	1219	1206	1184		1154	1139	1126	1117	1101	1082	1062	1049	1029	1019	1010	1002
W_t+E_c	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41	-41		-40	-40	-40	-40	-40	-40	-40	-40	-40	-41	-41	-41
t_c	1330	1312	1295	1278	1265	1248	1228	1209	1196	1178	1166	1144		1114	1099	1086	1077	1061	1042	1022	1009	989	978	969	961

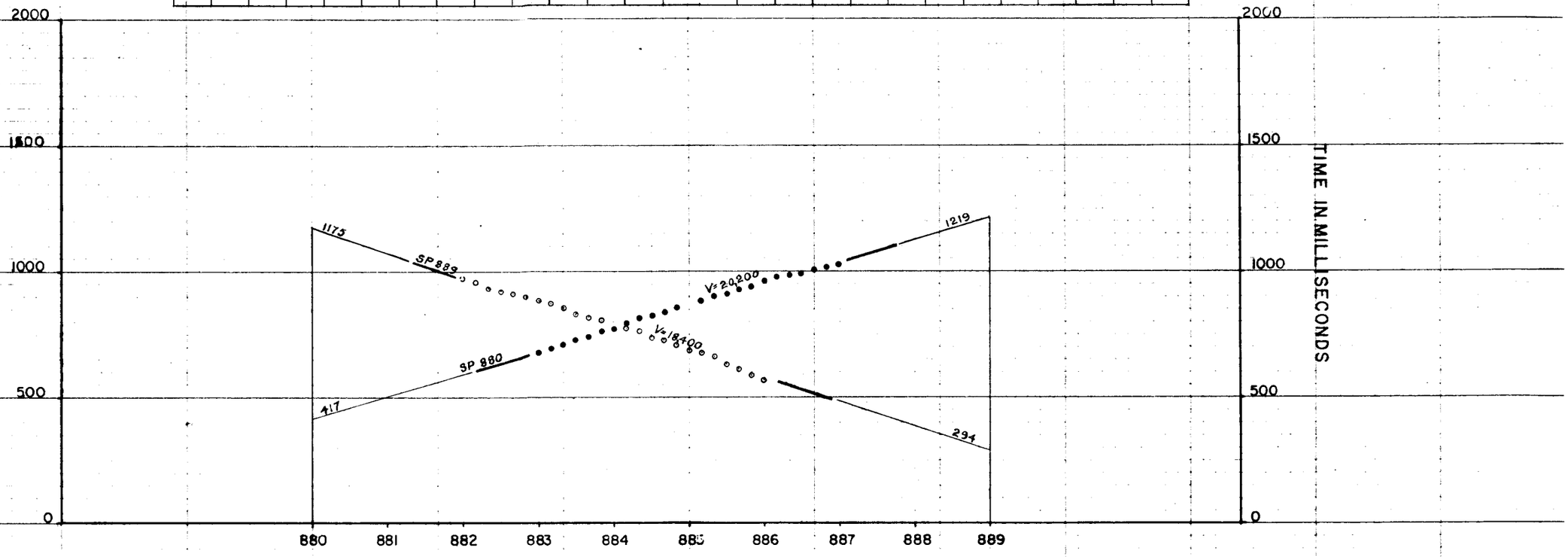


Geophysical Branch, Bureau of Mineral Resources Geology and Geophysics. G55/B3-33
TO ACCOMPANY RECORD NO. 1966/144

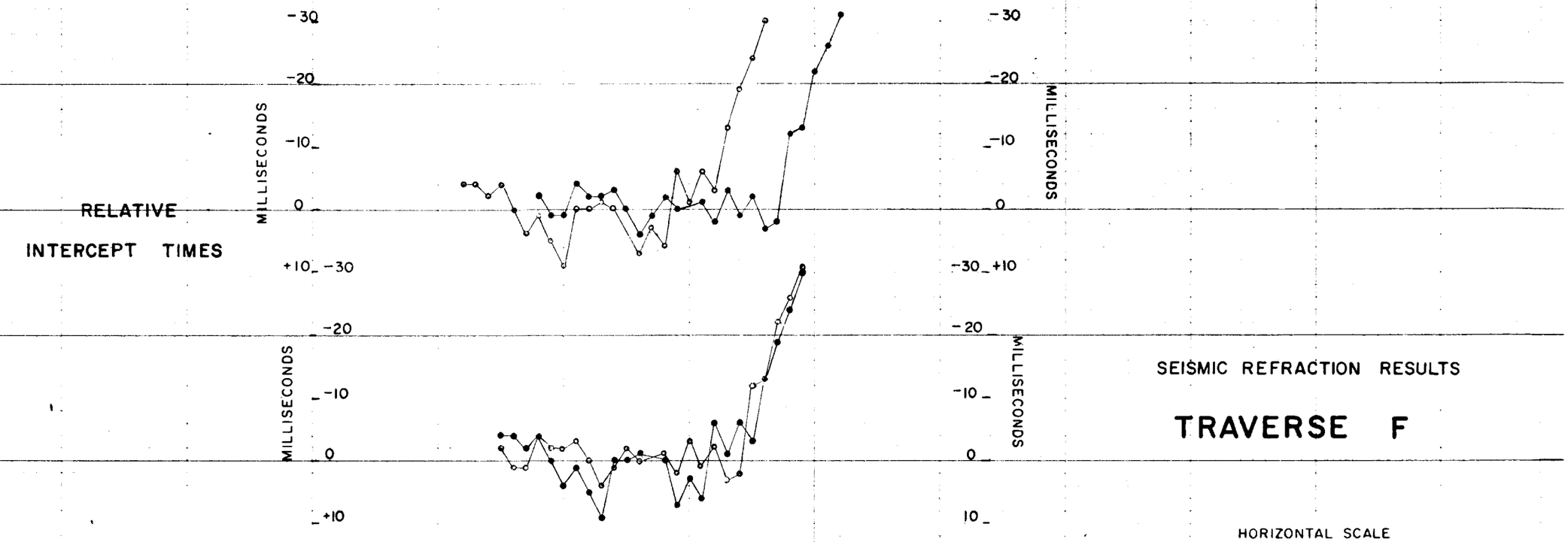
PLATE 10

	24	23	22	21	20	19	18	17	16	15	14	13	SP880	12	11	10	9	8	7	6	5	4	3	2	1
t_o	771	729	745	756	773	789	803	821	841	853	866	883	SP 885	914	932	944	963	976	997	1011	1013	1026	1033	1045	1055
We+Ec	-32	-32	-32	-32	-32	-32	-32	-31	-31	-31	-31	-31		-31	-31	-32	-32	-32	-32	-32	-32	-31	-31	-31	-31
t_c	679	697	713	724	741	757	771	790	810	822	835	852		883	901	912	931	944	965	979	981	995	1002	1014	1024

	24	23	22	21	20	19	18	17	16	15	14	13	SP889	12	11	10	9	8	7	6	5	4	3	2	1
t_o	1002	987	973	955	945	933	915	903	891	867	851	835	SP 884	804	795	775	753	735	724	705	691	667	645	624	603
We+Ec	-32	-32	-32	-32	-33	-33	-33	-33	-33	-33	-33	-33		-33	-32	-32	-32	-32	-32	-32	-32	-33	-33	-33	-33
t_c	970	955	941	923	912	900	882	870	858	834	818	802		771	763	743	731	703	692	673	659	634	612	591	570

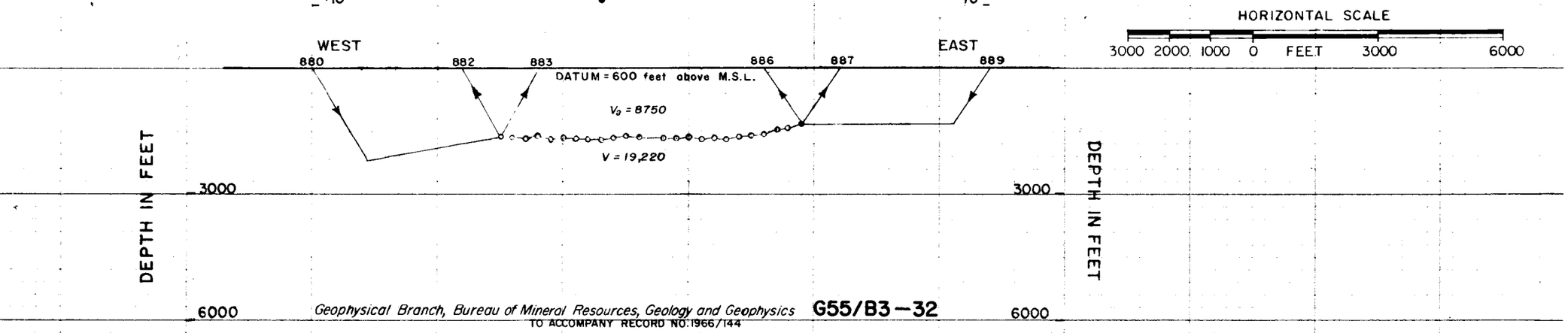


RELATIVE INTERCEPT TIMES



SEISMIC REFRACTION RESULTS

TRAVERSE F



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics **G55/B3—32**
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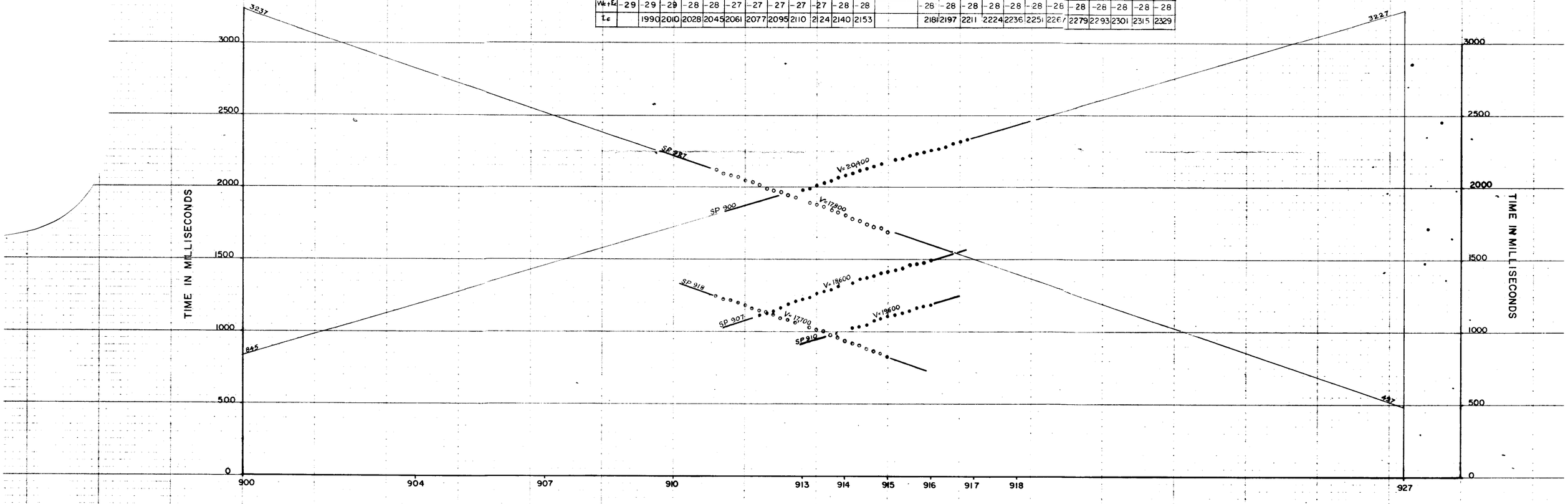
PLATE II

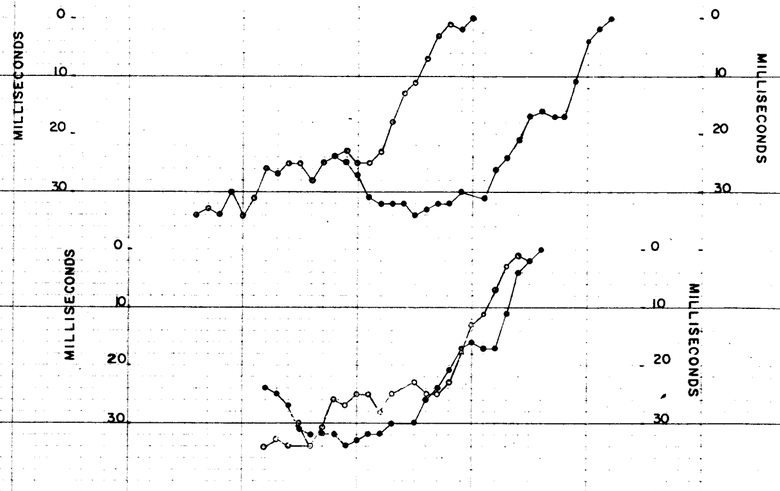
SP 927

	24	23	22	21	20	19	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1
t_o	2145	2128	2111	2094	2082	2063	2042	2027	2009	1995	1982	1964	SP 913	1930	1916	1899	1881	1859	1838	1821	1801	1781	1765	1750	
Wef$_c$	-33	-33	-33	-34	-34	-34	-34	-34	-34	-35	-35	-35		-35	-35	-34	-34	-33	-33	-33	-33	-33	-34	-34	-34
t_c	2112	2095	2078	2060	2048	2029	2008	1993	1975	1960	1947	1929		1895	1881	1865	1847	1826	1805	1788	1768	1748	1731	1716	

SP 900

	24	23	22	21	20	19	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1
t_o		2019	2039	2057	2073	2089	2104	2122	2137	2151	2168	2181	SP 915	2209	2225	2239	2252	2264	2279	2295	2307	2321	2329	2342	2357
Wef$_c$	-29	-29	-28	-28	-27	-27	-27	-27	-27	-27	-28	-28		-28	-28	-28	-28	-28	-28	-28	-28	-28	-28	-28	-28
t_c		1990	2010	2028	2045	2061	2077	2095	2110	2124	2140	2153		2181	2197	2211	2224	2236	2251	2267	2279	2293	2301	2315	2329





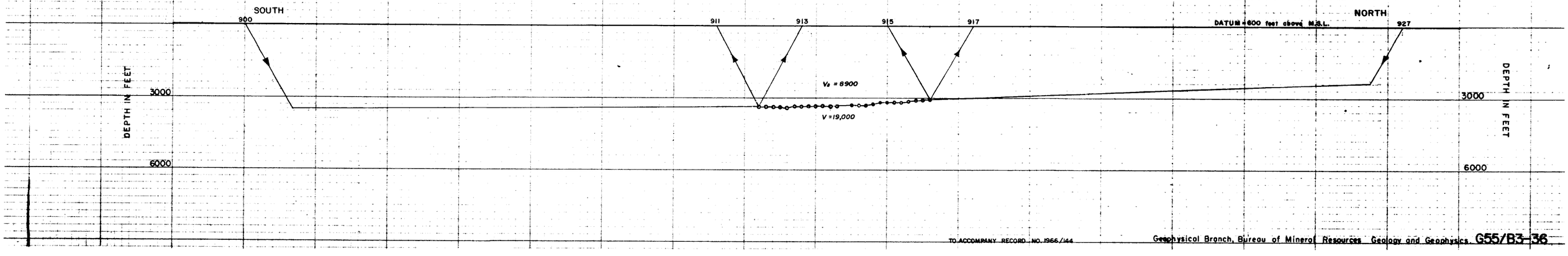
RELATIVE INTERCEPT TIMES

SEISMIC REFRACTION RESULTS

TRAVERSE G

HORIZONTAL SCALE

3000 2000 1000 0 FEET 3000 6000



TO ACCOMPANY RECORD NO. 1966/144

Geophysical Branch, Bureau of Mineral Resources Geology and Geophysics. G55/B3-36

PLATE 12

SP839

	24	23	22	21	20	19	18	17	16	15	14	13	SP834	12	11	10	9	8	7	6	5	4	3	2	1
t_o	907	893	888	872	861	848	837	827	809	791	773	758		721	706	692	678	665	648	633	614	600	583	567	549
Wc+Ec	-30	-30	-30	-29	-29	-29	-29	-29	-29	-30	-30	-30		-30	-30	-30	-30	-30	-30	-30	-30	-30	-30	-30	-30
t_c	939	923	918	901	890	877	866	856	838	821	803	788		751	736	722	708	695	678	663	644	630	613	599	579

SP830

	24	23	22	21	20	19	18	17	16	15	14	13	SP835	12	11	10	9	8	7	6	5	4	3	2	1
t_o	504	523	534	553	571	586	599	609	623	637	653	669		704	718	732	749	762	777	794	806	819	833	852	871
Wc+Ec	-28	-28	-28	-29	-29	-29	-29	-29	-29	-29	-29	-29		-29	-29	-29	-29	-29	-29	-29	-29	-29	-29	-29	-29
t_c	532	551	562	582	600	615	628	638	652	666	682	698		733	747	761	778	791	806	823	835	848	862	881	900

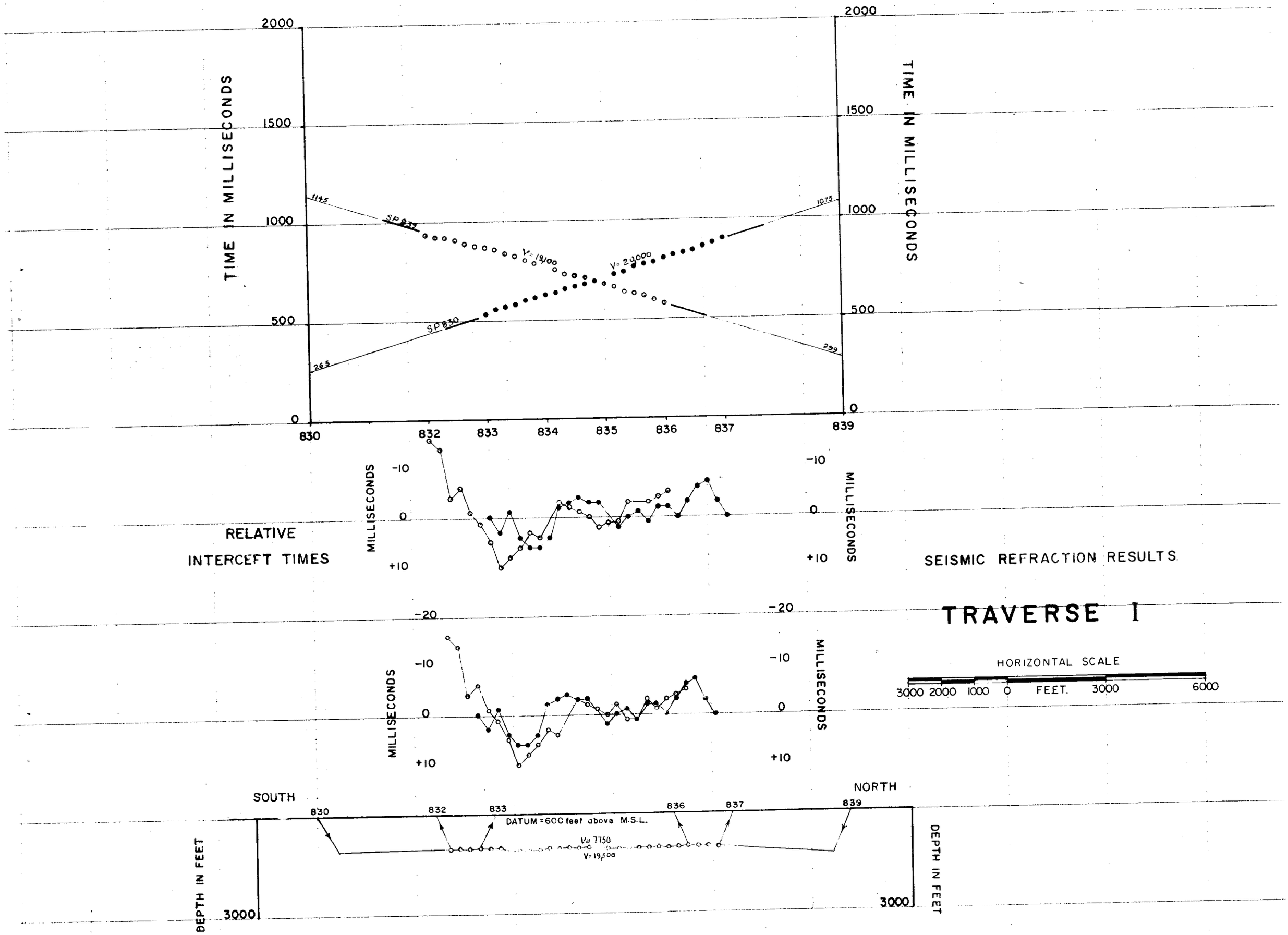


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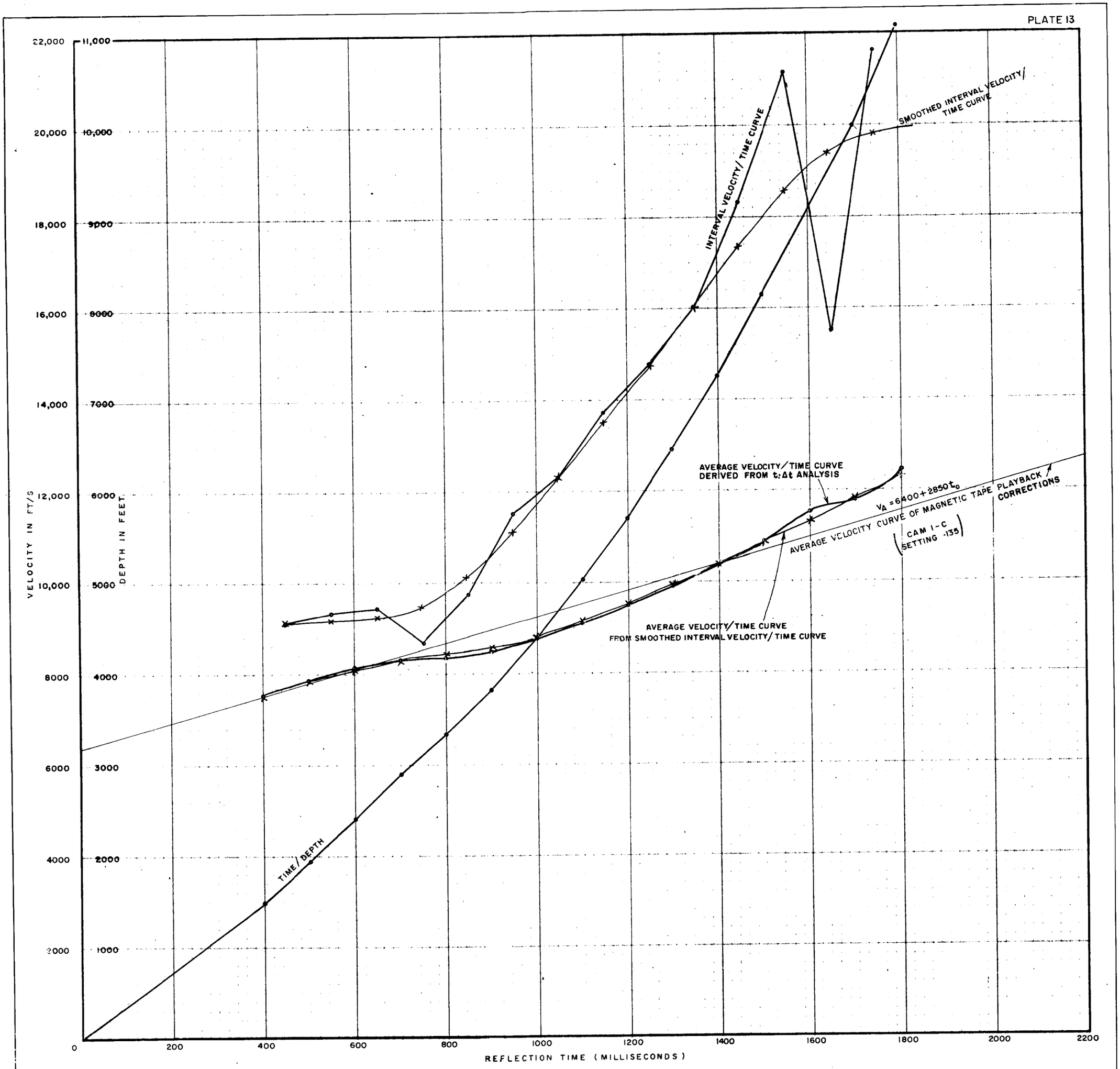
PLATE 13



TRAVERSE A { SP 1–20 (120 POINTS); SP 80–100 (160 POINTS); SP 700–720 (120 POINTS) }

CURVES FROM t:Δt ANALYSIS (400 POINTS)

AVERAGE VELOCITY, DEPTH, INTERVAL VELOCITY IN RELATION TO REFLECTION TIME

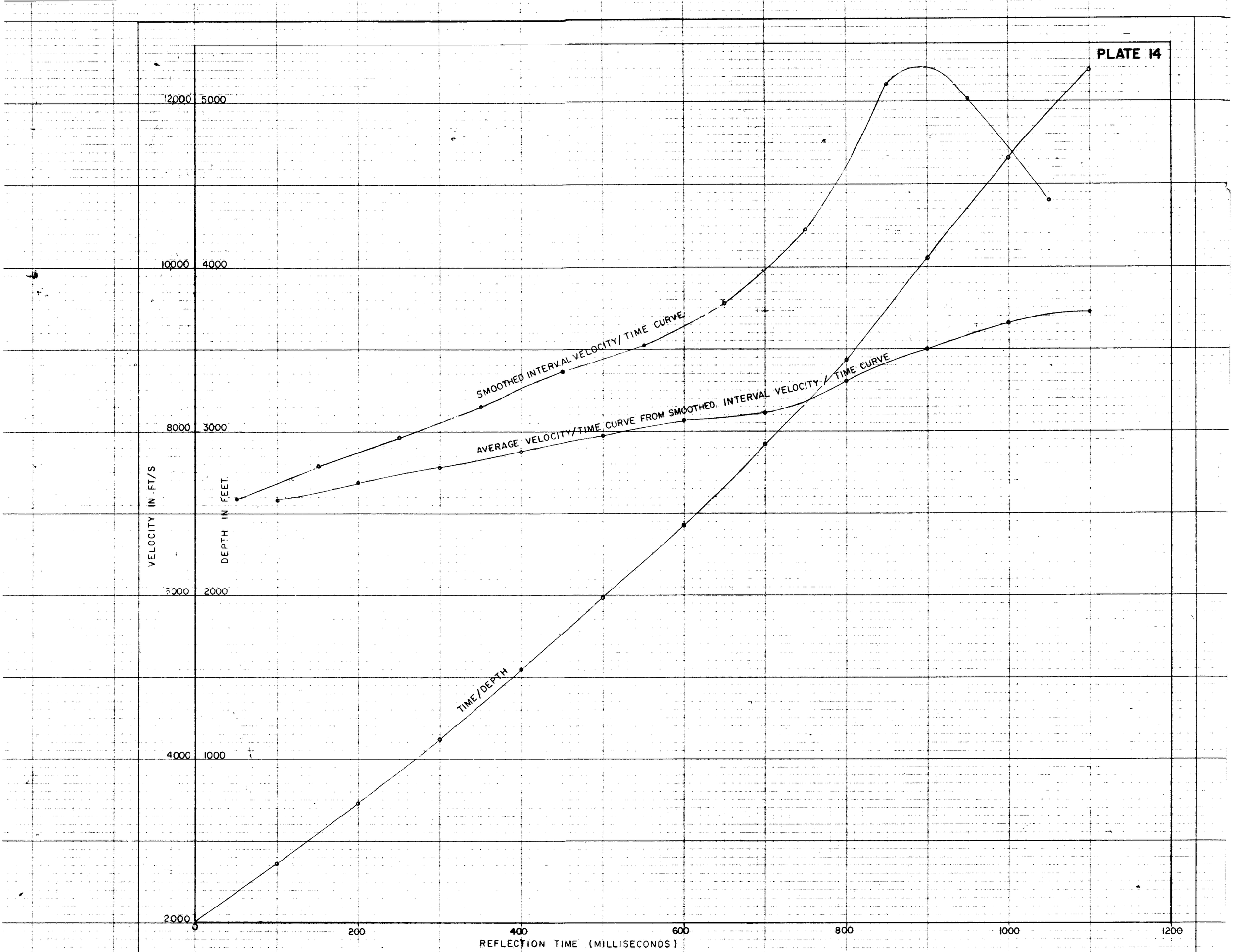
GOONDIWINDI AREA

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G55/B3-21 - 2

TO ACCOMPANY RECORD No. 1966 /144

SURAT BASIN 1961

PLATE 14



TRAVERSE D SP 811–816 (22 Points)

TRAVERSE A SP 636–651 (31 Points)

CURVES FROM tΔt ANALYSIS (53 Points)

AVERAGE VELOCITY, DEPTH, INTERVAL VELOCITY

IN RELATION TO REFLECTION TIME.

BOOLBA AREA

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G55/B3-37

TO ACCOMPANY RECORD NO. 1966/144