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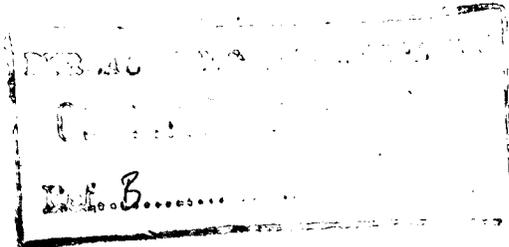
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DEPARTMENT OF NATIONAL DEVELOPMENT

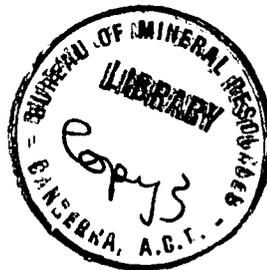
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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RECORD No. 1962/133



**SURAT BASIN SEISMIC
RECONNAISSANCE SURVEY,
QUEENSLAND 1960**



by

E. R. SMITH and K. B. LODWICK

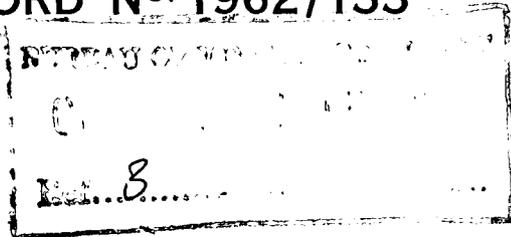
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SUMMARY.

Reflection and refraction seismic work was done in 1960 to complete a reconnaissance survey which was commenced in 1959 across the northern part of the Surat Basin. A reconnaissance line now extends in an easterly direction from 30 miles west of Surat to Jondaryan, and this line is also tied to the geologically well-known Roma area.

Two good marker horizons have been established in the seismic work - one a strong reflector and the other a refractor in which the velocity averages 19,000 ft/sec and which may represent basement.

A deep trough of sediments, possibly 20,000 ft thick at Meandarra, exists between Surat and Tara, and there is a large uplift west of Tara. The eastern margin of this large trough is 12 miles east of Tara, but sediments about 4000 ft thick probably continue to the east, at least as far as Jondaryan.

1. INTRODUCTION

In 1958 a seismic party from the Bureau of Mineral Resources carried out a short experimental seismic survey in the Surat area of the Surat Basin (Morton and Robertson, 1959). More-extensive seismic reconnaissance work was done in 1959 from Surat to Tara (Lodwick and Watson, 1960). Traverses were shot using the continuous-profiling seismic reflection method over five-mile intervals with spaces of from five to ten miles between the traverses. Near Cabawin (Plate 1) an anticline was discovered that was of sufficient interest to warrant further investigation.

This Record describes some further seismic work done in the Surat Basin by a Bureau seismic party from March to July 1960. The work was done on both the eastern and western ends of the Surat/Tara traverse of 1959 (Plate 1), and also between Roma and Surat. The purposes of this seismic work were:

- (a) to extend the Surat/Tara traverse to the eastern margin of the Surat Basin.
- (b) to complete the seismic reflection survey across the Cabawin structure.
- (c) to extend the Surat/Tara seismic traverse farther west in the direction of the Nebine Ridge.
- (d) to link the well-known geology of the Roma area to the Surat/Tara traverse by a reconnaissance reflection traverse.
- (e) to make refraction depth-probes at selected places in the Roma/Surat/Tara area of the Surat Basin, and in particular to measure depths to possible basement refractors at critical localities indicated by the refraction work.

The party's programme was assisted by information provided by Associated Australian Oilfields N.L. (AAO) from their seismic exploration in the Roma district, and also by seismic records supplied by the Australian Oil and Gas Corporation (AOG) (and its associated companies, Union Oil Development Corporation and Kern County Land Company) from between Cabawin and Tara (Union Line UT, Plate 1). The Union Oil Development Corporation and their contractors, United Geophysical Company, have supplied variable-area cross-sections using the Bureau's magnetic tapes and their own. The variable-area cross-sections are shown on Plates 9 to 13.

A great deal of seismic exploration has been done by AAO and AOG and their associated companies during and since the Bureau's Surat Basin 1960 seismic survey and several bores have been drilled (including AAO Timbury Hills No. 2, AAO Pickanjinie No. 1 and Union Kern AOG Cabawin No. 1). Some of the exploration work has been subsidised by the Commonwealth Government.

2. FIELD WORK

A list of the personnel and equipment used by the Bureau seismic party is shown in Appendix A; the Table of Operations (Appendix B) includes information on the technical aspects of the survey (surveying, drilling, and recording).

Most of the time allotted to the survey was spent in the Tara area, i.e. the eastern end of the Surat/Tara traverse and the following work was completed in this area (Plate 1 shows the location of the traverses named).

- (a) Continuous reflection profiling was completed over the Cabawin structure and extended down the eastern flank of the structure to within 5 miles of Tara (Traverse G).
- (b) The regional traverse was extended eastward by continuous reflection profiling from Tara to Weranga (Traverse G).
- (c) Five 5-mile traverses of continuous profiling spaced about five miles apart were completed between Weranga and Jondaryan (Traverses J and K).
- (d) Refraction traverses were shot to record velocities in the Meandarra syncline (Traverse H), on the crest of the Cabawin anticline (Traverse I), and in the shallower eastern part of the Surat Basin (Traverse L).

In the Surat area the following work was completed (traverses are again shown on Plate 1):

- (a) Two short reflection traverses, one $7\frac{1}{2}$ miles long and the other 4 miles long, spaced about 3 miles apart were surveyed along the Roma/Surat road using the continuous reflection profiling technique (Traverse A).
- (b) Two 5-mile traverses spaced about 8 miles apart and located west of Surat were surveyed by continuous reflection profiling (Traverse M).
- (c) A refraction traverse was surveyed south of Roma (Traverse N).

In the Tara/Cabawin area, normal shooting depths were between 100 and 150 ft and record quality improved with increasing charge, although 20 to 30 lb was normally used. However, east of Tara the thickness of the weathered layer varied considerably, and best shooting depths ranged from 70 to 200 ft in quite short distances. This rapid variation was apparently associated with lateritic deposits on the area of outcrop of the Blythesdale Group. Farther east, shooting conditions varied from traverse to traverse, as did the velocities recorded on the first breaks. This may be attributed to the fact that the line passed over strata of varying lithology as they cropped out towards the eastern margin of the Surat Basin. Near Jondaryan between Shot-points 811 and 816 (Plate 2), basalt was encountered in some shot-holes and no reflections were recorded over this portion of the traverse.

In the Roma/Surat area, shooting and drilling conditions were variable. Lateritic surface formations were encountered on Traverses A and M and depth of weathering varied from place to place. On the southern part of Traverse A, circulation was lost in sandy material and shot-holes were difficult to load.

On Traverse M, which is west of Surat, a nine-hole pattern shot was fired at Shot-point 2167 over lateritic deposits. Some improvement in reflection quality resulted with shot-holes drilled to 120 ft depth.

3. GEOLOGY

Whitehouse (1954) gave an account of the geology of the Great Artesian Basin, which includes the Surat Basin. Lodwick and Watson (1960) gave an outline of the geology as it concerns the seismic surveys of the Surat Basin.

The seismic survey of 1959 (Lodwick and Watson, 1960) indicated a thickness of at least 14,000 ft of sediments in a trough, between Surat and Tara, with its axis near Meandarra.

Near Cabawin a strongly anticlinal structure, probably eroded on the crest, was discovered. Lodwick and Watson (1960) have suggested that the Meandarra syncline represents the southern extension of the Bowen Basin, and that the Cabawin structure forms part of the Hunter-Bowen Thrust Belt (Whitehouse, 1954).

4. PRESENTATION OF RESULTS

Reflection work

The magnetic tape recordings made by the Bureau in 1959 and 1960 on Petroleum Permit No. 57P were lent to Union Oil Development Corporation, whose contract company, United Geophysical Company, processed the tapes in their 'Strataprint' system. The Strataprints are variable-area cross-sections which provide an excellent form of presentation. Copies of these cross-sections, which were supplied by Union Oil Development Corporation, have been used to present the results in this report. Thus, some of the results of the reflection traverses of the 1959 survey are presented here again, in variable-area form. The table below shows the details of the Strataprint cross-sections included in this Record:

<u>Traverse</u>	<u>Shot-points.</u>	<u>Plate</u>	<u>Year of Survey</u>
A	2044-2059	9	1960
AA	52-62	10	1959
E	192-378	11	1959
F	174-179	10	1959
G	402-466	12	1959
G	467-605	12	1960
H	1031-1043	13	1960
I	1115-1123	13	1960
M	2101-2187	11	1960

Plates 12 and 13 include reflection work that was done by United Geophysical Company for Union Oil Development Corporation during 1960 (UGC Lines UF and UT); it was included in these Strataprint cross-sections because it ties in with the Bureau's reflection work.

The Strataprint variable-area cross-sections have been plotted with respect to linear time, and the scale is exaggerated in the horizontal direction. They have been photo reduced for presentation in this Record, and the horizontal scale may be ascertained from the distance between shot-points, which is a constant of 1320 ft. For the 1959 seismic survey, Lodwick and Watson (1960) used a datum of 700 ft above mean sea level. On the Strataprint cross-sections a datum level of 800 ft above mean sea level was used.

To aid in the regional geological interpretation of the seismic results, the main reflecting horizons, which can be correlated over large distances, have been depicted on two small scale cross-sections (Plates 2 and 3).

The positions of these horizons on the Strataprint cross-sections are shown by the figures 1 to 5 at the end, or at breaks in the traverses, and indicate the first to fifth horizons respectively, in the order of increasing reflection time (or depth). In some places it has not been possible to correlate the same horizon continuously and a second horizon has been drawn by correlating another prominent reflection.

When this is done, the new horizon is designated by adding an A for the horizon just above it, or to the horizon with which it probably correlates.

The records from Traverses J, K, and the northern part of Traverse A (Plate 1), which were not on Petroleum Permit 57P, have not been processed in variable-area form, and the results of these traverses are shown only on the small-scale correlation profiles (Plates 2 and 3) and have been drawn from corrected record cross-sections. The results along these traverses will be presented in variable-intensity form in the final report.

Records taken at the Timbury Hills No. 2 bore near Roma and also records taken on a traverse about 8 miles south of Roma (Plate 1) by Austral Geoprospectors Inc. for AAO have been made available to the Bureau. Information from these records is included on the correlation profiles.

The correlation profiles are plotted in depth using a time/depth conversion obtained from a t:Δt analysis made from results near Surat in 1958 (Morton & Robertson, 1959 and Lodwick & Watson, 1960).

The use of the t:Δt analysis from seismic results at Surat as the basis for time/depth conversion may not be valid over the deeper parts of the Surat Basin and it is probable that, when the results of the velocity survey of the Cabawin No. 1 bore (Union-Kern AOG) are published, some alteration in the time/depth scale will be necessary. Two bores at Roma have been surveyed for velocities, with Bureau assistance, and the time/depth relationship obtained may be applicable to the shallow basement areas of the Surat Basin (Smith & Lodwick, 1960, Lodwick & Smith, 1960). In the meantime, however, the time/depth relationship derived from the t:Δt analysis was applied throughout the whole of the Bureau seismic survey in the Surat Basin.

Refraction work

Four refraction traverses were shot in the Surat Basin using the 'refraction depth probing technique' (Vale and Smith, 1960). Traverse H was surveyed in the Meandarra syncline (Plate 1), and an attempt was made to record all refractors possible; Traverse I was located as near as possible to the crest of the Cabawin anticline; Traverse L was located on the shallower portion of the Surat Basin east of the Cabawin anticline; Traverse N was surveyed over a portion of the Roma/Surat road where reflection profiling had been done by Geoprospectors for AAO. The results of the refraction work on the four traverses, in the order listed above, are shown on Plates 4, 5, 6, and 7 respectively.

The refraction-shooting statistics are shown in Appendix B. The refraction interpretation at the bottom of the plates is based on the recording of a recognisable phase of the first arrival of the energy on the records, except in the case of the deepest refractor along Traverse H where the times of events arriving after the first arrivals were used for the interpretation. So that the weathering and elevation corrections for the refraction surveys would be small, different datum planes, below which the depths were measured, were used. The datum planes corresponding to each refraction traverse are shown on the plates.

The various refractors recorded on each of the traverses are plotted at their calculated depths on the reflection correlation profiles (Plates 2 and 3).

5. INTERPRETATION

In this general discussion of the interpretation of seismic results in the Surat Basin, results have been included from the previous two surveys made by the Bureau in the Basin. The interpretation is based mainly on the following two correlative horizons

- (a) No. 4, the deepest of the reflection horizons depicted in the correlation profiles, is the most characteristic and is generally recorded by a strong reflection that can be 'character' correlated from shot-point to shot-point, and across gaps between traverses. This horizon will be referred to as the 'L' horizon.
- (b) a high-velocity refractor in which the velocity is roughly 19,000 ft/sec was recorded on all refraction traverses; this refractor gave a good correlative horizon that could be compared with the reflection cross-sections. It is not necessarily certain that this refractor represents basement, or even the same type of formation at each locality, but it can be assumed that the sediments extend at least to the depth of this refractor. Henceforth this refractor will be referred to as the 'basement' refractor. It has been plotted at its measured depth on the cross-sections shown on Plates 2 and 3.

Ten miles south-east of Roma, the 'basement' refractor was calculated to be 4000 ft below sea level. Reliable reflections were recorded to almost this depth, but there was no reflection that could confidently be correlated with the refractor. The characteristic 'L' horizon does not show up in this area. Near Roma, bores have encountered a granitic or metamorphic basement (Timbury Hills Formation) at about 3000 ft below sea level. It seems reasonable to correlate the refractor with this basement and therefore on this basis between Roma and this point there is an increase of 1000 ft in the sedimentary sequence. The reflection profiles indicate that this increase in thickness of sediments is maintained to the south-east through Surat. At Surat, the 'L' horizon can definitely be recognised and is calculated to be at 5500 ft below sea level. About eight miles north-east of Surat, the 'basement' refractor was recorded along a refraction traverse from a calculated depth of 5700 ft below sea level. This depth corresponds closely to the depth to the 'L' horizon at this locality, and the two may correlate here.

Referring to the results along the traverses that make up the long east-west profile, those west of Surat are poor in quality but appear to indicate a westward thinning of about 1000 ft in the sedimentary sequence. To the east, the reflection cross-section shows a steady increase in the sedimentary sequence to as far as Glenmorgan. In particular, the 'L' horizon reaches a calculated depth of 13,700 ft below sea level between Glenmorgan and Meandarra before it starts to rise gradually again. About 12 miles east of Surat the 'basement' refractor has been calculated to be at a depth of 7400 ft below sea level which is 900 ft below the 'L' horizon; at about 12 miles north-east of Meandarra, it is calculated to be 18,400 ft below sea level and 6500 ft below the 'L' horizon. Thus between Glenmorgan and Meandarra, the 'basement' refractor is probably more than 20,000 ft below sea level and an equivalent thickness of sediments can be expected there. This large thickening of sediments from Surat, about 15,000 ft, has mainly occurred in two zones of the sequence. There is a calculated increase of about 5000 ft between the third horizon and the 'L' horizon, and of about 6500 ft between the 'L' horizon and the 'basement' refractor.

Between Meandarra and Tara, the cross-sections indicate a major uplift north of Cabawin. The calculated depth to the 'basement'

refractor on top of this uplift is 9100 ft below sea level. Correlation of the 'L' horizon across this uplift is not possible, owing to probable faulting on the western flank of the uplift and also because it appears that this horizon may have been eroded from the top of the structure. The eastern flank of the uplift is more gentle than the western flank. A second trough is formed with its axis near Tara. A depth measurement to the 'basement' refractor was not made in this trough. However, the reflection cross-sections indicate a minimum depth of sediments of 10,000 ft, the true depth probably being closer to 15,000 ft. Two reflection horizons that could possibly correspond to the 'L' horizon are at depths of 7700 ft and 8900 ft below sea level in the Tara trough.

The eastern margin of this trough of sediments appears to be about 12 miles east of Tara. The reflection cross-sections give evidence of a marked thinning of the sediments in this vicinity, with some steep west dips recorded that may indicate faulting along the margin. The 'basement' refractor was recorded at 3000 ft below sea level about 14 miles east of Tara. The margin as defined by the seismic work coincides closely with a steep gravity gradient (measured by Australian Oil and Gas Corporation) which is positive to the east. From this point to Jondaryan, about 50 miles farther east, the record-quality is variable but is generally poor. However, the cross-sections indicate that about the same thickness of sediments, viz. 4000 to 5000 ft, can be expected along this part of the traverse.

The seismic results relative to the main trough near Meandarra may be interpreted in terms of stratigraphic succession in the following ways:

- (a) the indicated increase in thickness between the third horizon and the 'L' horizon may represent an introduction of Palaeozoic (probably Permian) sediments below the Mesozoic, and the increase in thickness below the 'L' horizon may represent further Palaeozoic (probably pre-Permian) sediments,
- (b) the indicated increase in thickness between the third horizon and the 'L' horizon may represent an increase in thickness in the Lower Mesozoic formations (Triassic), and the increase in thickness below the 'L' horizon may represent Palaeozoic (probably Permian) sedimentation.

6. REFERENCES

- | | | |
|----------------------------------|------|---|
| LODWICK, K.B. and SMITH, E.R. | 1962 | Pickanjinie No. 1 bore seismic velocity survey near Roma, Queensland 1960. <u>Bur. Min. Resour. Aust. Record</u> 1962/52. |
| LODWICK, K.B. and WATSON, S.J. | 1960 | Surat Basin seismic reconnaissance survey Queensland 1959. <u>Bur. Min. Resour. Aust. Record</u> 1960/107. |
| MORTON, A.G. and ROBERTSON, C.S. | 1959 | Experimental seismic survey, Surat, Queensland. <u>Bur. Min. Resour. Aust. Record</u> 1959/13. |
| SMITH, E.R. and LODWICK, K.B. | 1962 | Timbury Hills No. 2 bore seismic velocity survey Queensland 1960. <u>Bur. Min. Resour. Aust. Record</u> 1962/51. |

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- VALE, K.R. 1960 A discussion on corrections for weathering and elevation in exploration seismic work, 1959. Bur. Min. Resour. Aust. Record 1960/13
- VALE, K.R. and SMITH, E.R. 1961 The 'depth probing' technique using seismic refraction methods. Bur. Min. Resour. Aust. Record 1961/79
- WHITEHOUSE, F.W. 1954 Artesian water supplies in Queensland; Appendix G - The geology of the Queensland portion of the Great Australian Artesian Basin. Govt Printer, Brisbane

APPENDIX A

STAFF AND EQUIPMENT

STAFF:

Party leader:	E. R. Smith
Geophysicists:	A. Turpie J. S. Davies K. B. Lodwick
Surveyors:	R. Parker W. L. Richards) Assisted by students
Clerk:	W. E. Rossendell
Observer:	G. L. Abbs
Shooter:	E. H. Cherry
Toolpushers:	L. Hodgins J. G. Halls
Drillers:	L. Sprynskyj B. G. Findlay
Mechanics:	I. D. Pirie H. Robertson
Wages Employees:	Up to nine

EQUIPMENT:

Seismic amplifiers:	TIC model 621
Seismic oscillograph:	TIC 50-trace, 10 in. mixing
Magnetic recorder:	Electro-Tech DS7-1
Geophones:	TIC 20 c/s and 6 c/s
Drills:	Failing 750 Carey type H1 for air fluid and water
Water tankers:	2 International 3-ton, 4 x 4; 2 Bedford 3-ton, 4 x 4
Shooting truck:	Commer 3-ton, 4 x 4

APPENDIX B

TABLE OF OPERATIONS

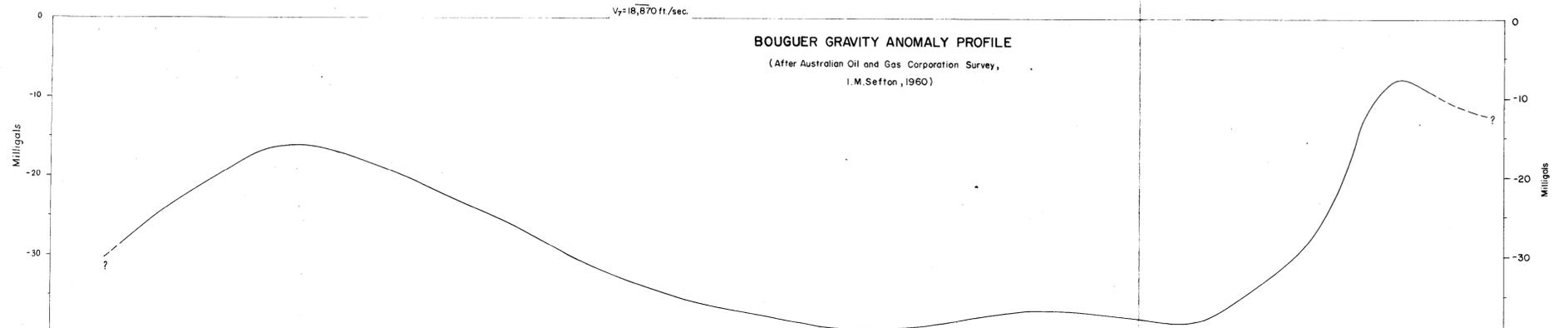
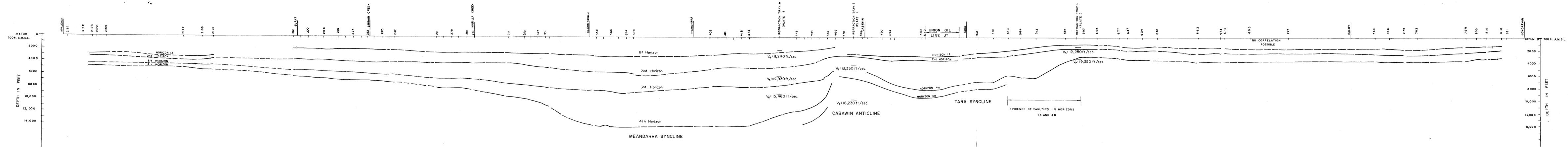
Sedimentary Basin:	Surat Basin part of Great Artesian Basin
Area:	Cabawin/Jondaryan and Roma/Surat
Camp sites:	Goranba and Paradise Creek
Established camp:	22.3.60 at Goranba; 24.6.60 Paradise Creek
Surveying commenced:	23.3.60
Drilling commenced:	25.3.60
Shooting commenced:	25.3.60
Miles surveyed:	150
Topographic survey control:	Queensland Dept. of Lands, Parish and 2-mile maps
Total footage drilled:	51,382
Explosives used:	14,000 lb
Datum level for corrections:	700 ft for reflection
Weathering velocities:	2000 to 3000 ft/sec
Sub-weathering velocities:	6000 to 7000 ft/sec
Source of velocity distribution:	that analyses - Lodwick & Smith (1962) and Smith & Lodwick (1962)

REFLECTION SHOOTING DATA

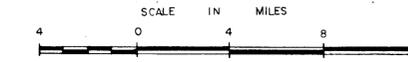
Shot-point interval:	1320 ft
Geophone group:	six geophones, 20 c/s, in line
Geophone group interval:	22 ft
No. of holes shot:	413
Common shooting depths:	70 to 200 ft
Usual recording filter:	L2H3
Usual playback filter:	L2H4
Common charge sizes:	10 to 25 lb
Weathering corrections:	After Vale (1960)

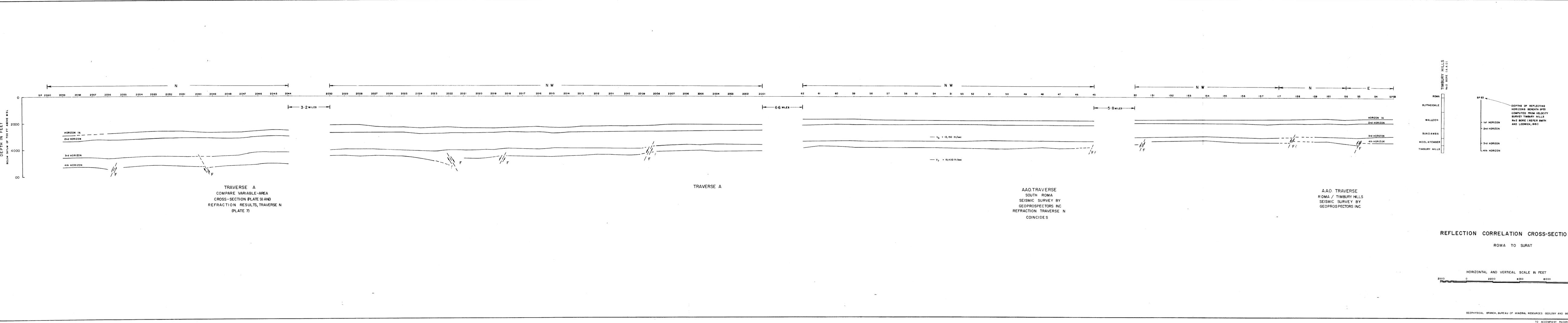
REFRACTION SHOOTING DATA

Geophone group:	Two geophones, six c/s, together
Geophone group interval:	220 ft
No. of holes shot	45
Usual recording filter:	LOH4
No. of refraction traverses:	4
Charge sizes:	20 to 500 lb
Maximum shot/geophone distance:	12 miles
Weathering control:	From reflection shooting and weathering spreads
Weathering and elevation corrections:	After Vale (1960)

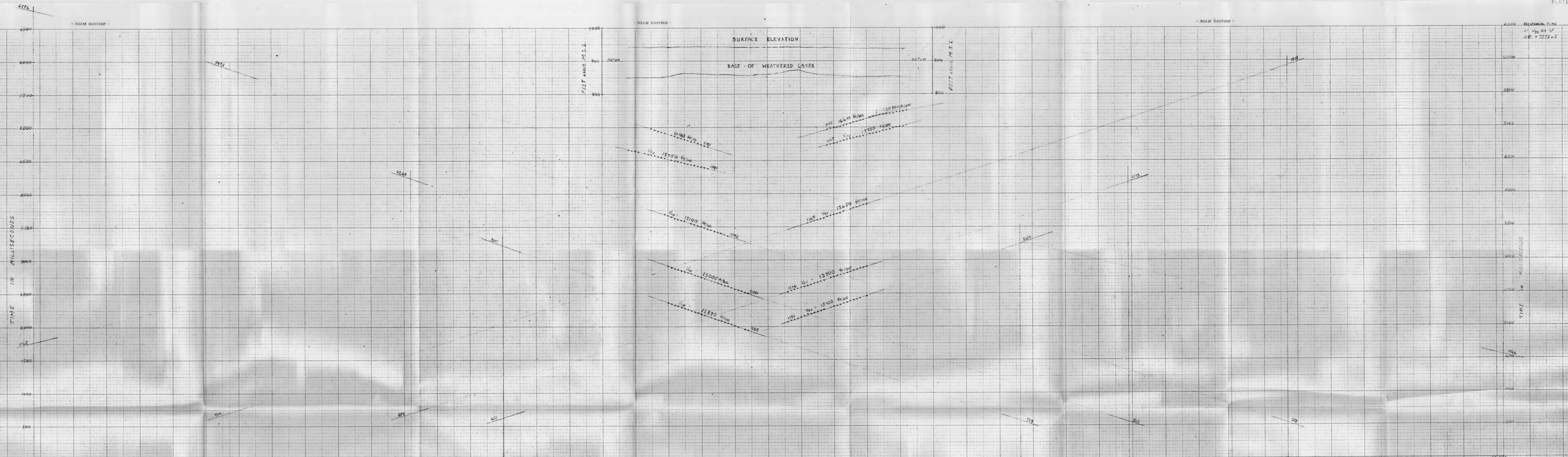


**SURAT TO JONDARYAN
 REFLECTION CORRELATION
 CROSS-SECTION**





SURAT BASIN Q.L.D. 1960



SP 1100

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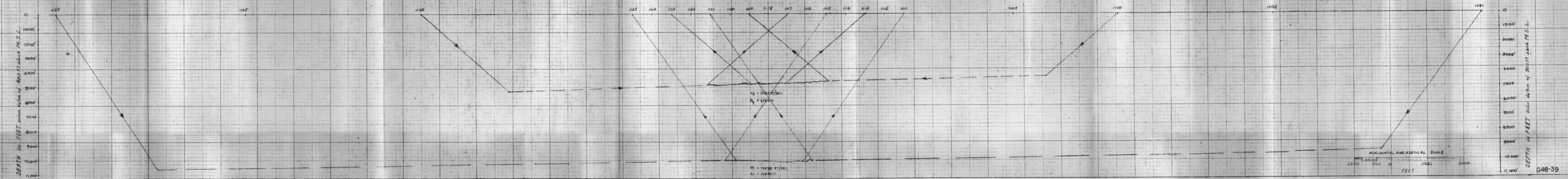
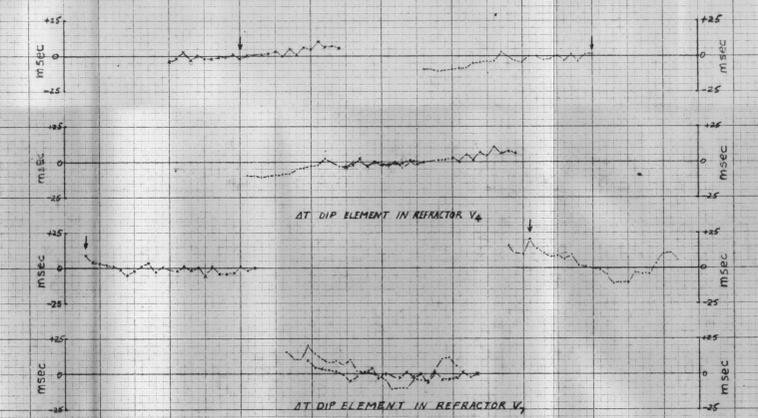
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SP 1136

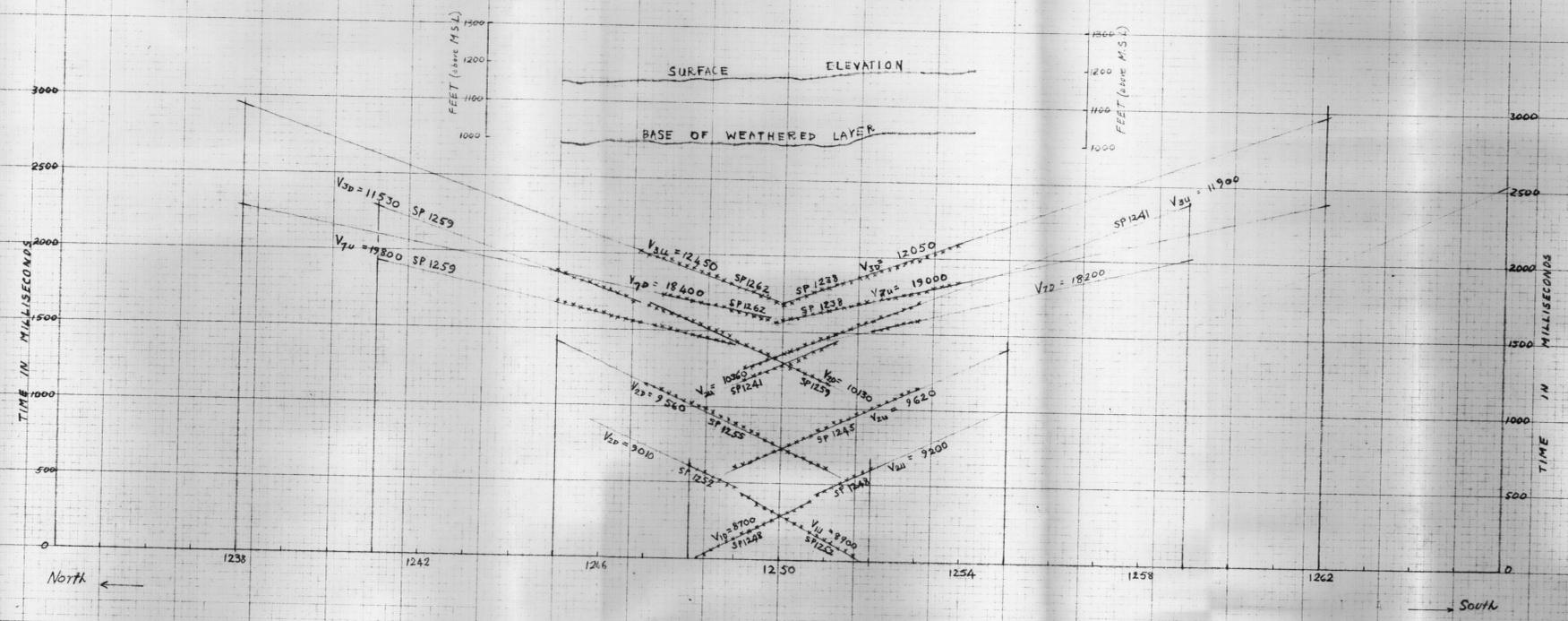
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SP 1155

1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200
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SURAT BASIN 1960
SEISMIC REFRACTION RESULTS
TRAVERSE I

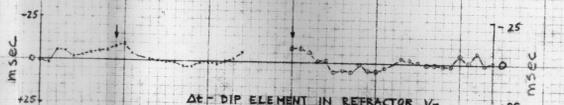
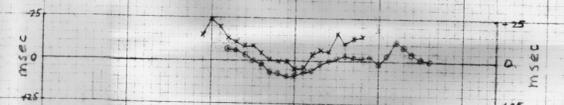
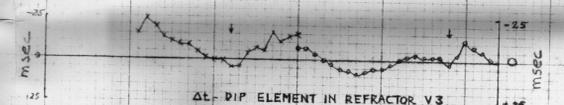


SP 1262

1246	1248	1250	1252	1254	1256	1258	1260	1262
2022	2034	2018	1980	1933	1918	1877	1854	1844
41	41	45	42	42	43	40	41	40
1624	1695	1969	1926	1891	1875	1857	1843	1830
1720	1705	1686	1678	1668	1657	1645	1633	1619
39	35	37	36	37	37	36	39	38
1629	1670	1651	1641	1632	1620	1608	1596	1583
1532	1521	1511	1501	1491	1481	1471	1461	1451

SP 1259

1245	1247	1249	1251	1253	1255	1257	1259	1261
1720	1705	1686	1678	1668	1657	1645	1633	1619
39	35	37	36	37	37	36	39	38
1629	1670	1651	1641	1632	1620	1608	1596	1583
1532	1521	1511	1501	1491	1481	1471	1461	1451



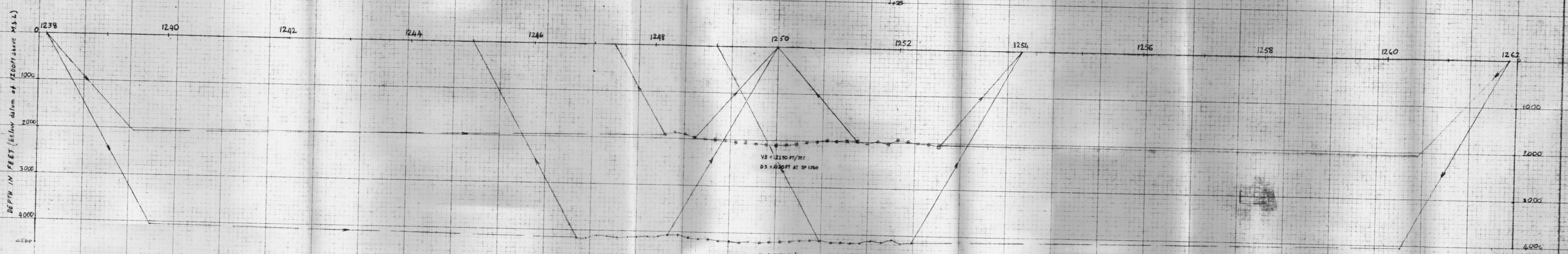
SP 1238

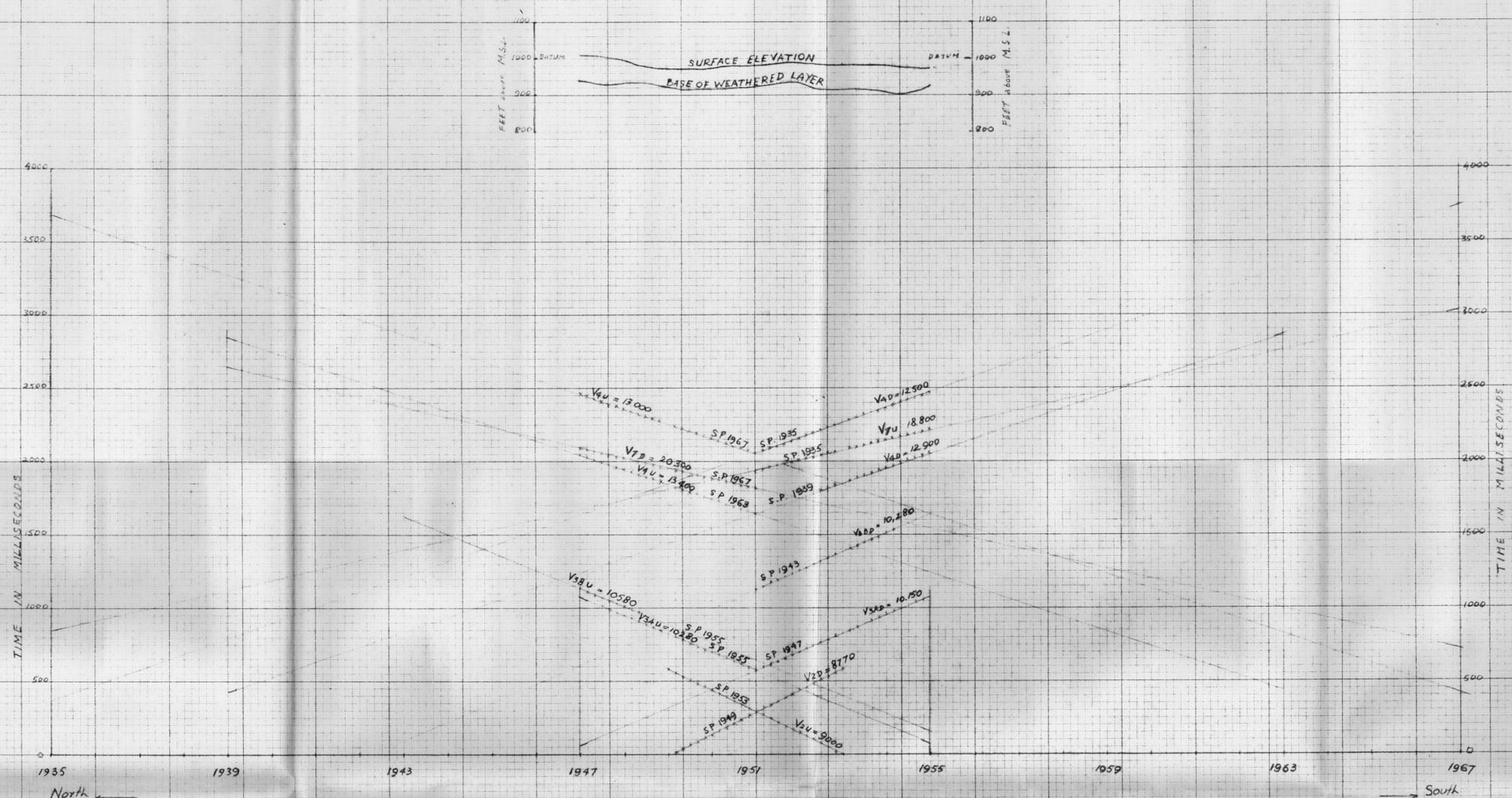
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1706	1721	1743	1764	1785	1806	1827
32	27	30	31	33	35	36
1624	1692	1734	1784	1835	1885	1935
1812	1829	1848	1866	1884	1902	1920
1871	1896	1911	1923	1932	1942	1951

SP 1239

1250	1252	1254	1256	1258	1260	1262
1601	1625	1641	1656	1675	1685	1694
30	29	30	31	33	34	35
1571	1596	1611	1623	1642	1652	1664
1743	1736	1745	1745	1753	1753	1753
1799	1799	1799	1799	1799	1799	1799
1802	1822	1828	1841	1841	1846	1877

SURAT BASIN 1960
SEISMIC REFRACTION RESULTS
TRAVERSE L





S.P. 1963

2173	2098	2076	2060	2040	2022	2006	1992	1972	1953	1935	1917	1884	1869	1856	1843	1822	1803	1785	1769	1750	1734	1719	1702
68	66	66	66	66	66	60	60	60	59	57	58	57	57	58	58	56	56	59	59	59	56	57	57
2051	2039	2020	1996	1977	1961	1948	1932	1912	1891	1878	1865	1825	1812	1798	1785	1766	1747	1728	1710	1697	1678	1662	1645

1947 1949 1951

S.P. 1939

1876	1894	1903	1939	1953	1975	1989	2008	2026	2049	2060	2072	2083	2097	2113
70	66	68	68	68	71	70	70	70	74	69	65	63	63	
1846	1834	1835	1877	1885	1907	1917	1936	1954	1973	1986	2003	2019	2035	

1951 1953 1955

S.P. 1967

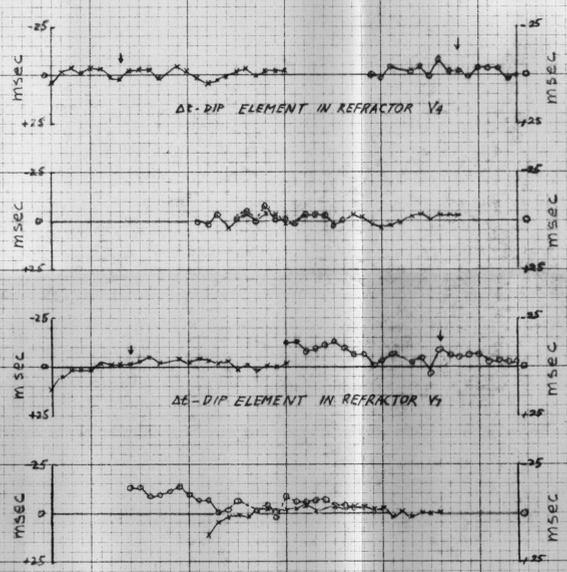
2173	2158	2144	2132	2118	2101	2090	2077	2067	2057	2050	2037	2008	1992	1979	1969	1958	1945	1930	1916	1902	1892	1879	
71	74	75	75	73	70	69	68	67	67	65	61	66	64	65	65	67	64	66	66	64	65	65	
2102	2087	2069	2057	2045	2031	2022	2009	1997	1984	1971	1965	1937	1928	1919	1909	1894	1881	1874	1864	1852	1838	1827	1814

1947 1949 1951

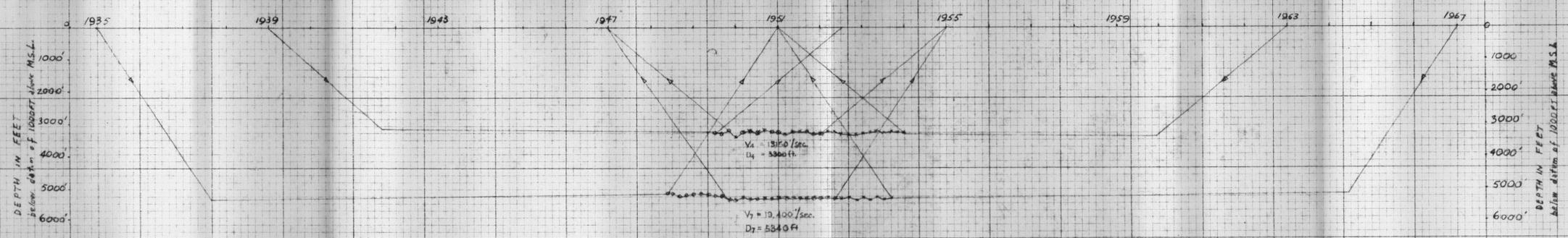
S.P. 1935

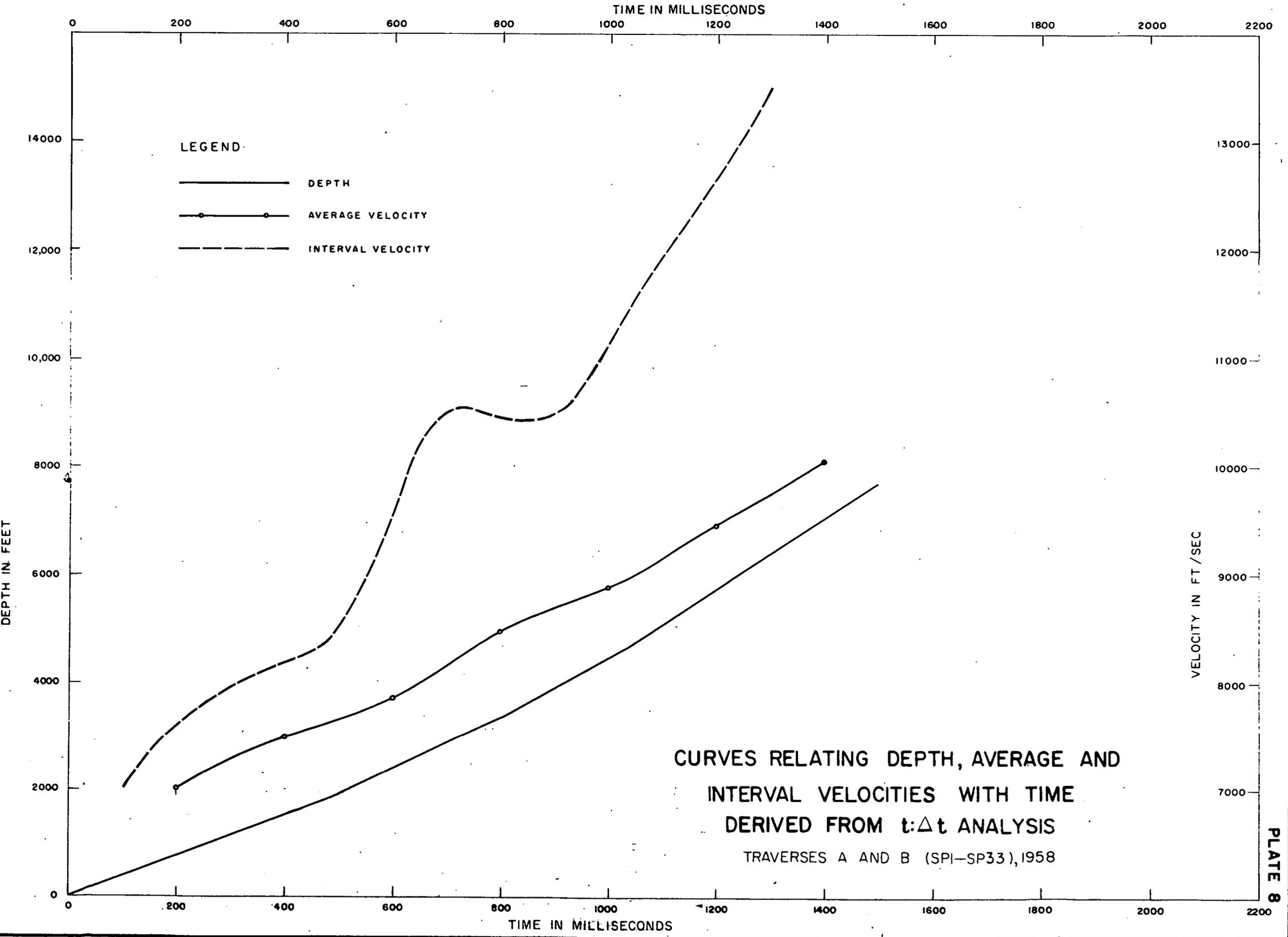
2001	2010	2020	2030	2047	2067	2072	2080	2094	2118	2125	2134	2164	2169	2189	2194	2205	2219	2223	2243	2252	2259	2270	2284
73	71	73	72	71	71	72	75	78	75	73	74	73	73	73	74	75	77	77	80	74	70	68	68
1928	1939	1956	1966	1976	1986	2004	2019	2034	2049	2052	2060	2087	2094	2116	2115	2130	2149	2162	2163	2174	2189	2202	2215

1951 1953 1955



SURAT BASIN 1960
SEISMIC REFRACTION RESULTS
TRAVERSE N

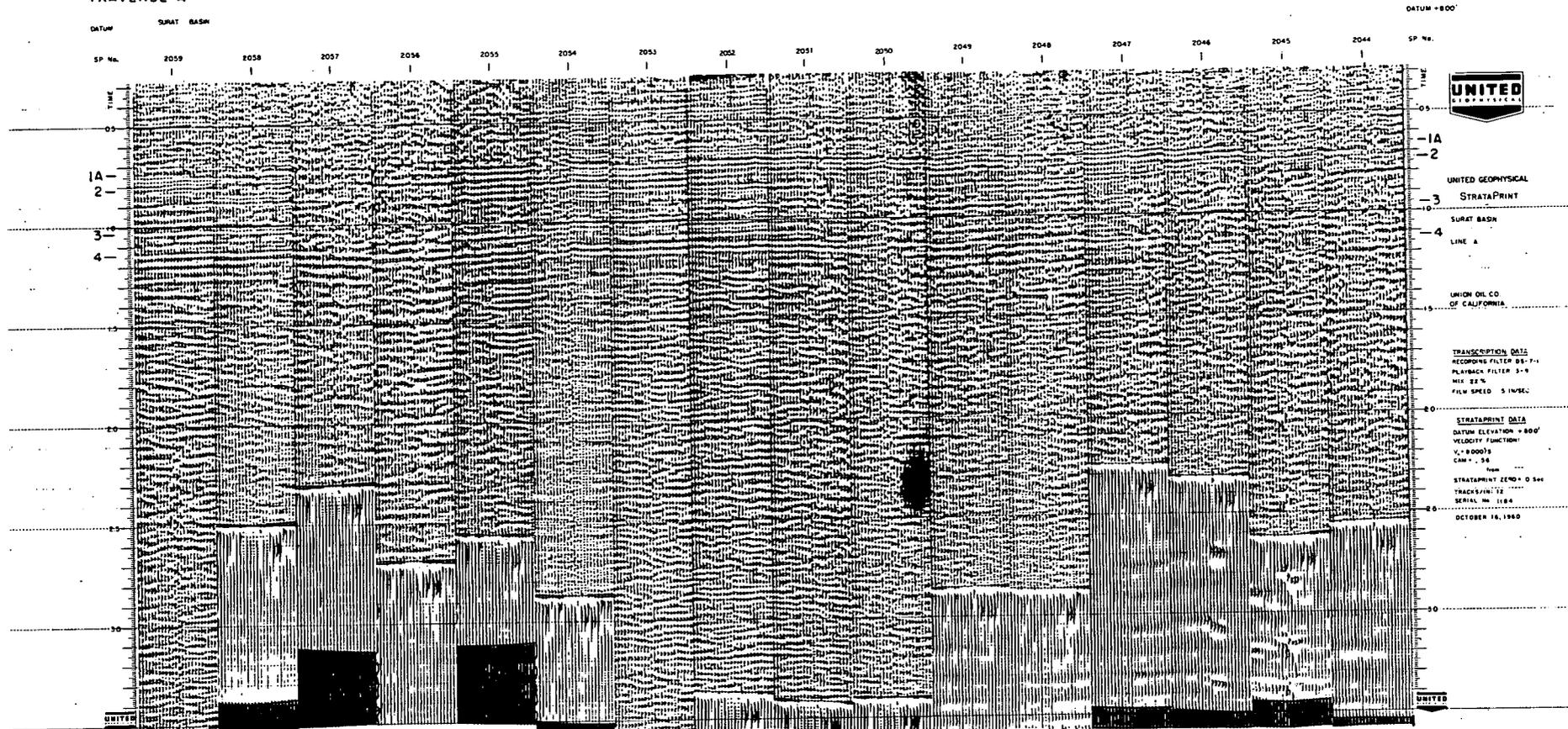




CURVES RELATING DEPTH, AVERAGE AND
 INTERVAL VELOCITIES WITH TIME
 DERIVED FROM $t:\Delta t$ ANALYSIS
 TRAVERSES A AND B (SPI-SP33), 1958

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics, G48-9-1
 TO ACCOMPANY RECORD No 1962/133

TRAVERSE A



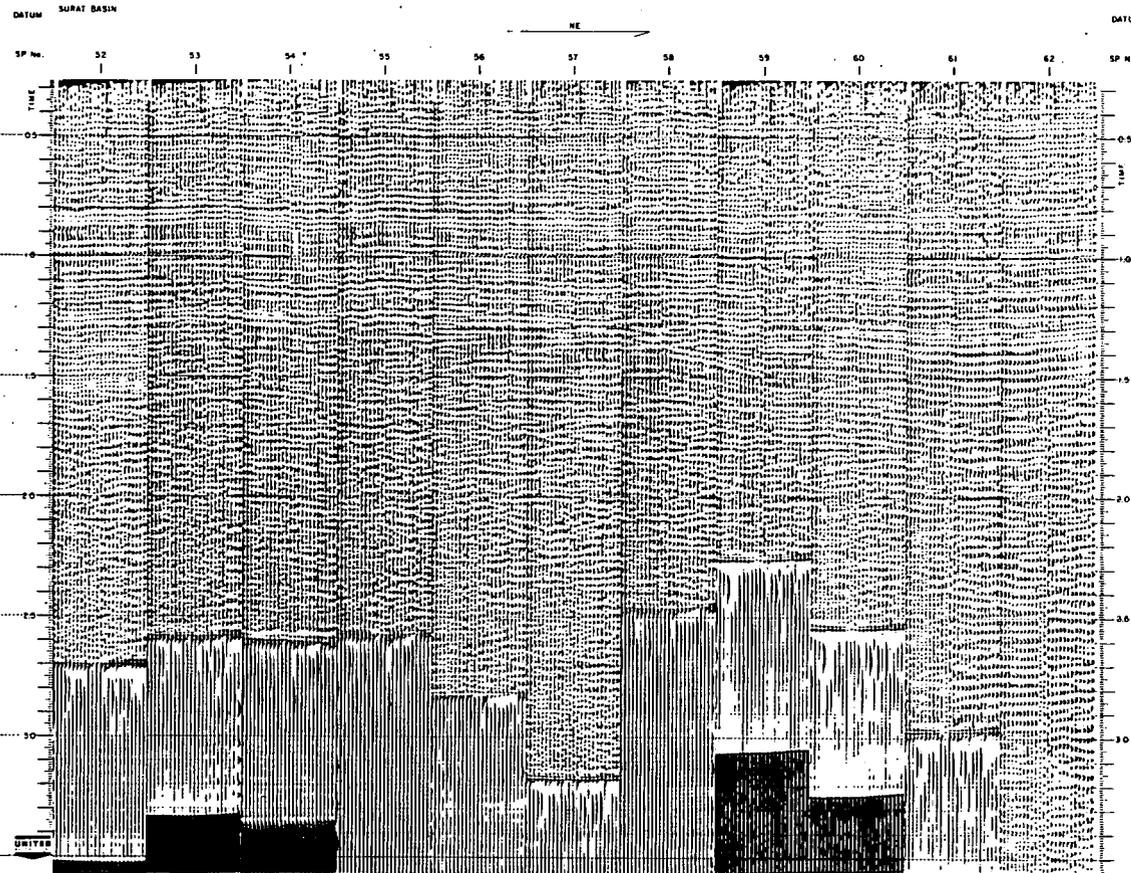
VARIABLE - AREA CROSS - SECTION

TRAVERSE A

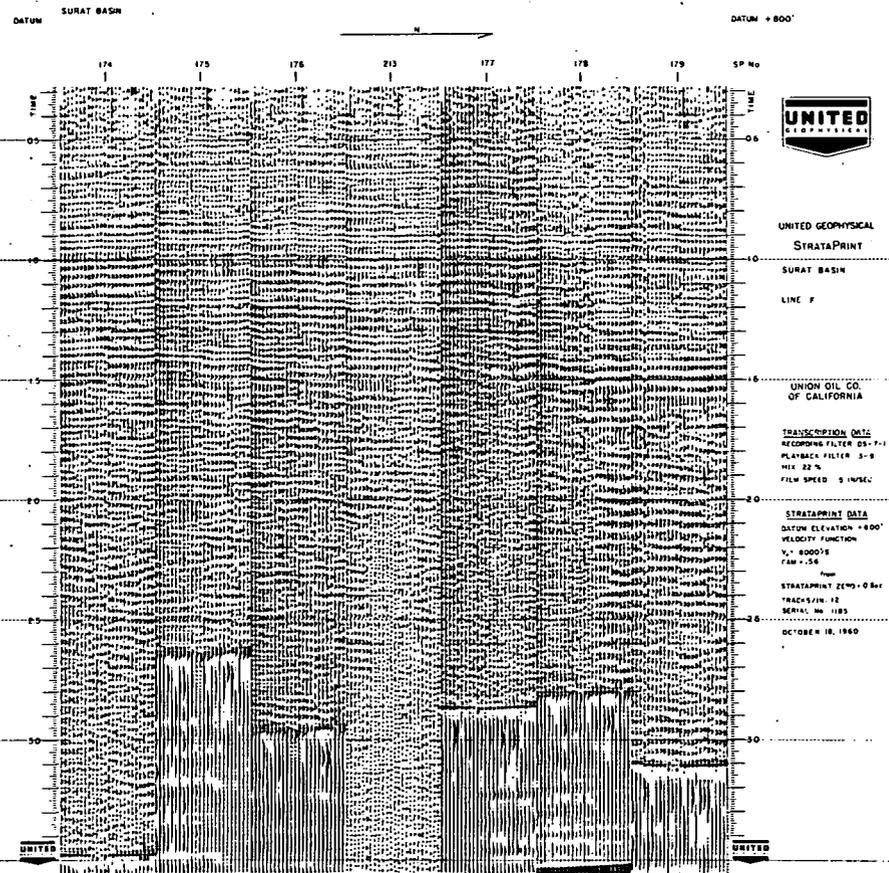
HORIZONTAL SCALE



TRAVERSE AA

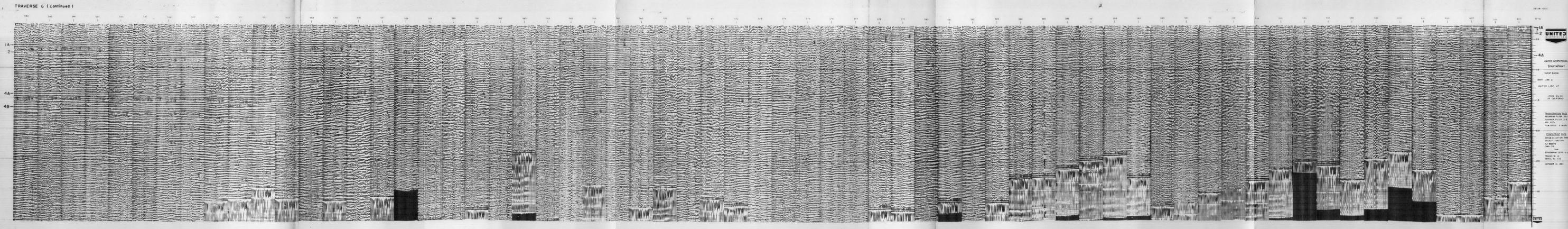
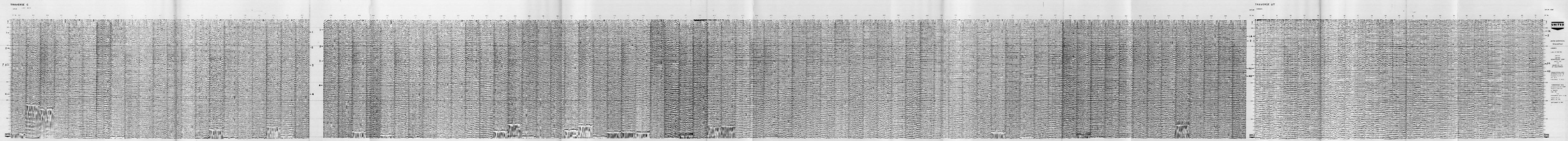


TRAVERSE F



VARIABLE - AREA CROSS - SECTIONS
TRAVERSES AA AND F

0 1320 2640 3960 5280 FEET



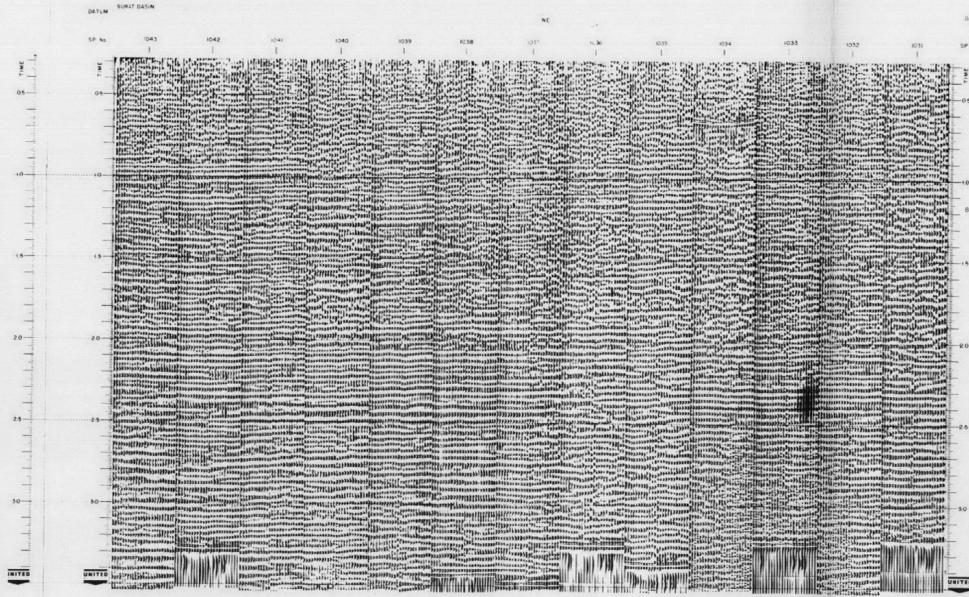
UNITED
 UNITED GEOPHYSICAL
 DIVISION
 1000 LANE 6
 UNITED LINE ST
 SUITE 200
 HOUSTON, TEXAS 77002



VARIABLE - AREA CROSS - SECTIONS
 TRAVERSES G (B.M.R.) AND
 UT (UNION OIL DEVELOPMENT)

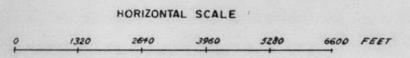
SURAT BASIN, 1960 944

TRAVERSE H

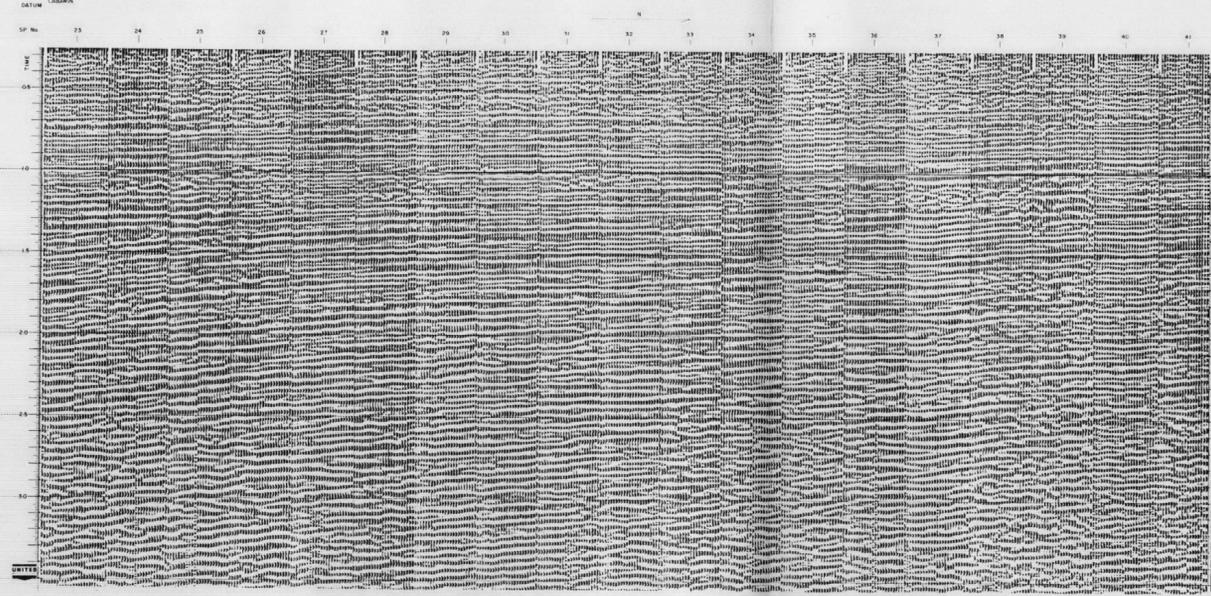


UNITED GEOPHYSICAL
 STRATAPOINT
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 SURVEY LINE H
 UNION OIL CO.
 OF CALIFORNIA
 TRANSCRIPTION DATA
 REGIONAL FILTER 2.5
 PLANAR FILTER 2.5
 100 200 300
 FILM SPEED 3 INCH
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 STATIONARY CORRECTION
 TRACKING IN
 DATE JULY 25, 1962

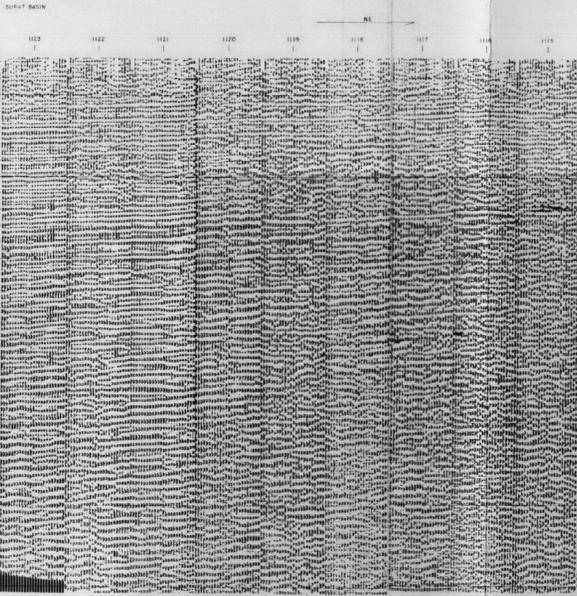
VARIABLE - AREA CROSS - SECTIONS
 TRAVERSES H AND I (B.M.R.)
 TRAVERSE U F (UNION OIL DEVELOPMENT)



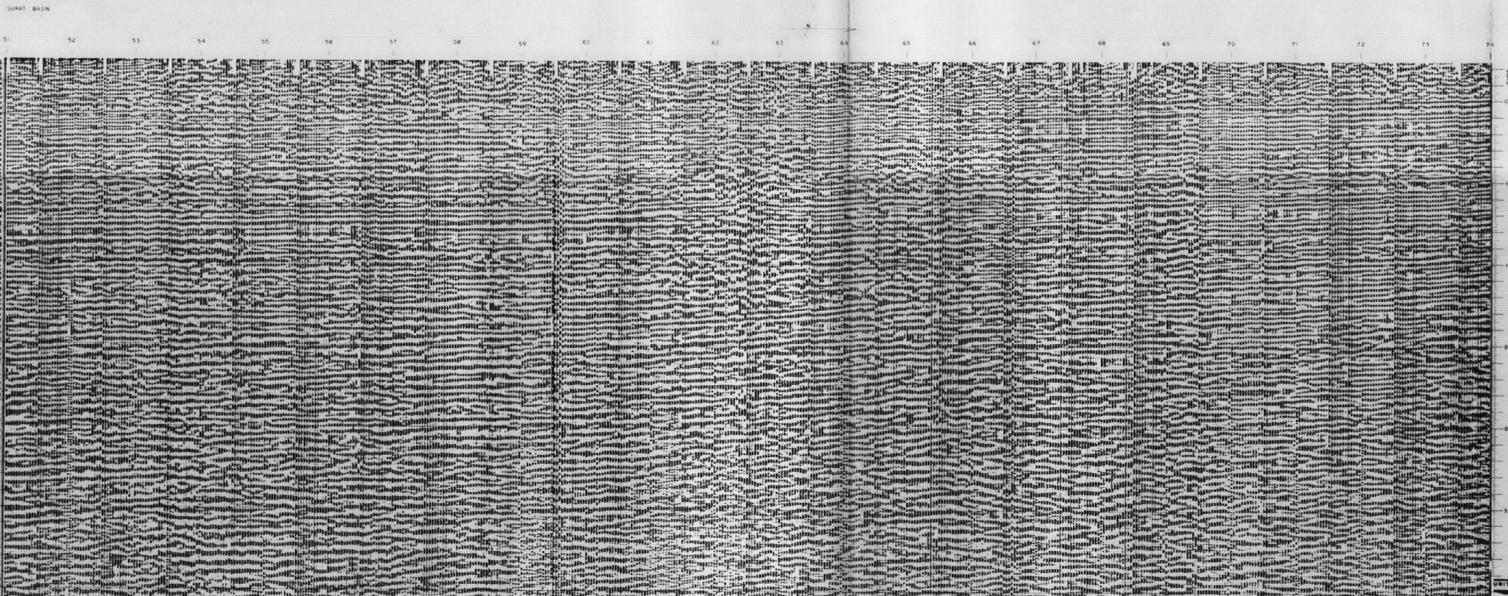
TRAVERSE U F



TRAVERSE I



TRAVERSE U F



UNITED GEOPHYSICAL
 STRATAPOINT
 SURVEY DATA
 SURVEY LINE U F
 SURVEYED BY
 UNITED GEOPHYSICAL CORP.
 PART 13
 UNION OIL CO.
 OF CALIFORNIA
 TRANSCRIPTION DATA
 REGIONAL FILTER 2.5
 PLANAR FILTER 2.5
 100 200 300
 FILM SPEED 3 INCH
 STATIONARY DATA
 DISTANCE ELEVATION 1400
 MAGNETIC CORRECTION
 1/2 INCH
 STATIONARY CORRECTION
 TRACKING IN
 DATE JULY 25, 1962