COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORDS 1959, No 13

EXPERIMENTAL SEISMIC SURVEY, SURAT, QUEENSLAND.

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CONTENTS.

PLATES.

ABSTRACT.

An experimental seismic survey was conducted at Surat, Queensland, on behalf of the Australian Oil and Gas Corporation Limited during a five week period from May 28th to July 2nd. 1958. The area lies within the southeastern portion of the Great Artesian Basin on Authority to Prospect No. 36P and, on the evidence of numerous bores near Roma, and a few other scattered bore logs, is considered to contain sediments suitable for the generation and accumulation of hydrocarbons in possible, economic quantities.

A local geological survey by the Australian Oil & Gas Corporation suggested a structure of considerable dimensions - the 'Weribone Uplift' - which, if substantiated, would provide a promising location for a stratigraphic test bore.

The experimental survey conducted by the Bureau showed that useful results could be obtained throughout the area by conventional methods of reflection and refraction shooting. The reflection shooting indicated a fairly uniform sedimentary section with generally flat-lying beds and a probable total thickness of 7,000 to 8,000 feet. The refraction work recorded several velocities including one near 19,000 f/s which is assumed to be a basement velocity. Depths measured to this high velocity refractor support the estimate of the thickness of sediments made from the reflection cross-section and indicate a south component of dip of about 40 ft. per mile across the area surveyed.

Neither the reflection nor the refraction work gave any evidence for the existence of the 'Weribone Uplift'. However, the more northerly refraction traverse indicated a local component of north dip at basement depth, and a single reflection record shot along that traverse suggested a substantial thickening of the deeper sediments towards the north. Insufficient seismic work was done to estimate the northwards extent of this dip. Such limited evidence might well indicate a purely local irregularity in basement topography. On the other hand, the north dip could be extensive, and therefore structurally significant. Any further seismic work contemplated in this area should be directed, in the first instance, towards checking this possibility.

1. INTRODUCTION.

The experimental seismic survey described in this report was undertaken by the Bureau of Mineral Resources, Geology and Geophysics at the joint request of the Queensland Mines Department and the Australian Oil and Gas Corporation Limited.

The area surveyed is situated in southern Queensland in the vicinity of Surat township (refer to plate 1), and lies within the area of the Company's Queensland Authority to Prospect No. 36P.

No mineral development exists within the area. Considerable flows of natural gas, and small quantities of oil have been found since 1900 in many of the bores which have been drilled in the adjacent Roma area but no major commercial supplies have been developed. However, this part of the Great Artesian Basin remains an area of potential interest and the Australian Oil and Gas Corporation requested the survey on the basis of a report by their geologist, T.B.H. Jenkins, on the "Geology of the Surat Inlier and its Structural Significance".

The primary object of the survey was to give the Company some idea of how useful a later and more extensive seismic survey of the 'Weribone Uplift' would be to determine a drilling location for an oil search bore. This involved determining the best seismic shooting technique on each of the geological formations occurring on the surface. As a secondary objective the survey might be expected to yield information on the probable thickness of the sedimentary section and, finally, it was hoped that a combination of reflection and refraction shooting might produce some evidence to support the uplift postulated by Jenkins.

The survey was conducted over a five week period from May 28th. to July 2nd., 1958.

2. GEOGRAPHY.

The Surat Inlier lies mainly south of the Balonne River, the alluvial flood plains of which define the northern and western limits of the area covered by the A.O.G. report, while to the east and south it is bounded by the ridges of laterised (Tertiary) sandstone.

Surat is 50 road miles S.S.E. from Roma, which is served by the main western railway from Brisbane; St. George, 75 miles S.S.W. of Surat is a district centre but has no railway. Glenmorgan, 39 miles east of Surat, however, is a subsidiary railhead.

Topographically the area is one of non-directionally rolling downs, which are abruptly terminated southward and eastward by the steep flat topped scarps of the Tertiary laterised sandstones. On the north and west the rolling downs merge with the Quarternary alluvium of the sluggish Balonne, or Condamine, River. "Black soil" covers the rolling downs country. The laterised sandstone gives rise to a clayey red soil, with ironstone nodules. Brown soils cover the alluvial tracts.

Climate is sub-tropical continental with wide seasonal extremes of temperature. Normally most of the rainfall occurs during the summer as torrential downpours. However, the experience of the Bureau's parties in the past indicates that some interference with field operations is liable to occur during the winter months also. The land is given over exclusively to pastoralism, with sheep rearing for wool as the main activity in the black soil tracts.

3. GEOLOGY.

The Great Artesian Basin of Eastern Australia has an area of at least 670,000 square miles on land, while another and very large area, of unknown extent, lies beneath the shallow waters of the Gulf of Carpentaria. 430,000 square miles of the coverage lies within the lands of the State of Queensland and constitute 64 per cent of the total area of Queensland.

A general description of the Basin, the succession of strata and the epeirogenetic movements responsible for the formation of the basin may be found in a paper by Whitehouse (1954). Two basement ridges are considered to divide the Great Artesian Basin into three sub-basins. One of these ridges, the Nebine Ridge, runs slightly east of north near meridian 147° east, and the second, the Euroka Shelf, runs east-west to the north of the Richmond-Cloncurry railway. The resulting sub-basins are named by Mott (1952) Carpentaria Basin for that section north of the Euroka Shelf, Surat Basin for the section east of the Nebine ridge, and the Eromanga Basin for the central and western part. This report is concerned only with the second of these, the Surat Basin, which has also been called (by Whitehouse and others) the Thallon Basin.

Stratigraphy of the Surat Basin.

The geological formations of the Great Artesian Basin have been studied in great detail on the eastern margin in Queensland. There the section ranges from Permain, through Triassic, Jurassic, and Cretaceous to Tertiary. The following summarised table is taken from Mott (1952, p.795).

Era.	Period.	Series or formation.	Description.
Tertiary	...	...	Non-marine. Sands, clays, calcareous deposits. Lignites, volcanics, laterite.
Mesozoic	Cretaceous	Winton	Lacustrine shales, coal.
		Tambo	Marine. Shales.
		Roma	Marine. Shales, sand lenses.
	Jurassic	Blythesdale Sandstone	Lacustrine to transitional Porous sandstones.
		Walloon Coal Measures	Lacustrine. Calcareous shales, sandstone. Coal measures.
	Triassic	Bundamba	Probably eolian and fluviatile.
		Sandstone	Sandstones, generally porous.
		Disconformity	(Angular unconformity established in Bowen Syncline, but probably does not exist in Surat Basin).

Era.	Period.	Series or formation.	Description.
		Ipswich Coal Measures and Moalayember Shales.	Lacustrine. Shales and sandstones. Coal measures.
		Clematis Sandstones.	Probably eolian or fluviatile. Red weathered sandstone.
		Rewan Formation	Lacustrine(?) Shales and sandstones. Chocolate and green in colour.
Palaeozoic	Permain	Upper Bowen	Lacustrine. Sandstone and shales with coal and oil shale.
		Middle Bowen	Alternating marine and non-marine shales and sandstones. Coal at base.
		Lower Bowen	Volcanics. Some marine.

Very little bore hole data exists within the area of interest, but at Roma, some 50 miles to the north-west, numerous boreholes have been drilled during the past half century. Many of these bores reached granite or metamorphic rock and in all cases the formations directly overlying the basement rocks are Triassic in age (Reeves 1947, p.1359).

The possible existence of Permian formations in the deeper portions of the Surat Basin is a matter of considerable interest and some conjecture. Whitehouse (1954) places the probable western limit of Permian sedimentation at about meridian 149° east in the latitude of Surat township. Our immediate area of interest lies to the west of this boundary and therefore, according to Whitehouse, Permian sediments would not be expected. He does suggest (p.12) however, that the Clematis and Moalayember formations (apparently petroliferous at Roma) might be expected to occur at depth.

Mott (1952) on the other hand is more optimistic when he states (p.859) that .... "The marine sediments of Permian age have been penetrated by three wells on the edge of the northern portion of the Surat Basin and were probably reached in a well at Wallumbilla"..... "Little is known of the distribution of these sediments beneath the Mesozoic rocks in the Surat Basin but it is known that they thicken eastwards across the Bowen Syncline and there is every possibility that they are present in the deeper regions of the Surat Basin".

It is known that the thickness of the Mesozoic (and Permian?) section exceeds 4,000 feet in the region of the Thallon axis, and reaches nearly 5,000 feet east of Roma and northwest of Surat, with a high probability of thickness greatly exceeding these in parts of the north-eastern quadrant of the Basin. This Basin is therefore considered to contain sufficient sediments of such a nature to generate and accumulate hydrocarbons in possible economic quantities.

Structure of the Surat Inlier.

As a result of Jenkins reconnaissance survey in late

1956, a more detailed survey was undertaken by the company. A total of 14 weeks was spent in the field. The work commenced as a detailed dip survey by Abney level and Brunton compass and later was directed towards establishing the identity and extent of outcrops of sandy sediments believed to represent the Blythesdale Group, probably the lowest formation exposed in the area. This mapping shows that the dips measured on the surface are scattered, but near Surat northerly dips predominate. The following discussion is based on Jenkins report.

Individual dips are insufficiently regular to indicate the regional strike and resort must be made to the areal distribution. The principal evidence for a regional strike at approximately N70°E lies in the distribution of the Roma-Blythesdale boundary. It should be noted, however, that this is an arbitrary line dividing a gradational series of sediments and therefore cannot be exactly drawn. Fortunately this line agrees with the distribution of the lower division of the exposed Blythesdale.

From the northerly dips and indicated strike it may be inferred that there is in the area mapped a general reversal of the regional southward dip anticipated in this part of the Surat Sub-Basin. The extent of outcrop of the Blythesdale Group determines an elevated structure, the "Weribone Uplift", incompletely exposed, which must continue some distance both east and west of the inlier under cover of Tertiary and Quaterniary sediments.

It is suggested that the magnitude of the structure ensures that it would persist at depth, and this can be justified to some extent by a study of bore logs. The base of the Blythesdale, not detected at the surface, is intersected in two bores within the Surat Inlier at elevations of about 400 and 500 feet above sea level. This horizon lies at a depth of 1,700 feet below sea level in a bore some 19 miles northwest of Surat. The principal Triassic aquifer is encountered at -2944 and -2581 feet respectively in these two bores but was penetrated at less than -2250 at a bore 11 miles southeast of Surat - how much less is uncertain because only the total depth is recorded; the flow, in quantity and quality, is such as can only come from the Triassic Bundamba aquifer.

To summarise these observations, the Weribone Uplift appears as a large elevated structure occupying the eastern central part of the northern Surat sub-basin. The probable minimum area of the regional closure as defined by the extrapolated Roma-Blythesdale boundary extends over a distance of 75 miles along the strike with a maximum width of about 25 miles. Closure exceeds 1,000 feet and may well be of the order of 2,000 feet; the structure persists with depth.

The Weribone Uplift tends to divide what has previously been called the Surat or Thallon Basin into two parts. the northern of which finds shallow expression in the Tinowon Syncline. The crestal area of the Weribone Uplift provides a likely site for local traps of the anticlinal kind. It seems reasonable to expect that a high basement would coincide with the axial part. Should this be so and the lower part of the expected Mesozoic sequence is found to be absent along the crest the best course would than be to probe the northern side of the rise for traps of some stratigraphic type.

In a personal communication (15/7/1958) received after the seismic survey was completed Dr. Jenkins advised an amendment to his report to the effect that "I now consider that what is shown and described as Roma Formation in that report is, on the presently available evidence, properly assigned to the upper (marine) part of the Blythesdale Group". He does not consider however, that this significantly affects his structural interpretation.

4. FIELD WORK.

The seismic party arrived at Surat on the evening of 28th. May, 1958, after travelling by road from Melbourne. Camp was set up near the Balonne River about one mile from Surat township and 30 feet above river level. Heavy rains caused a threatening rise in the river and, on 11th June, the camp was dismantled and the party moved to a house in the town.

The party was under the leadership of C.S. Robertson, assisted by F.J. Moss, six other staff members and 11 wages hands. In addition, A.G. Morton joined the party from June 9th. to July 1st. 1958 to become familiar with all details of the survey to facilitate joint authorship of the report.

Surveying for the party was carried out by a surveyor and two assistants furnished by the Australian Oil and Gas Corporation. T.B.H. Jenkins, in addition to advising on surface geology and traverse location, acted as liaison between the seismic party and local authorities, landowners and business people. His services in this capacity were most helpful.

Included in the party's equipment were two Failing 750 rotary drills and T.I.C. model 621, 24 channel recording equipment. Both 20 c.p.s. and 6 c.p.s. T.I.C. geophones were used during the survey.

Eighteen days were worked in the field, while seven days were lost due to rain. A total of 48 holes were shot along 11 miles of reflection traverses, and 11 holes were shot on the two short refraction traverses (refer to Plate 2). The total footage drilled during the survey was 7346 (see appendix for details) and 2500 lbs. of explosive (Geophex) were used.

Drill cuttings were sampled at 10 ft. intervals in each shot hole and these samples sent to the Geological Section of the Bureau for investigation. The samples were also examined by Dr. Jenkins and his interpretation of them has been used in compiling the shot hole logs shown on the reflection cross-section (Plate 4).

Traverse A - On alluvium.

On 30th. May seismic work commenced on two miles of reflection traverse surveyed along the main road to Roma immediately north of Surat township. This traverse was located to test shooting conditions on the alluvium. Uphole and downhole shots and two weathering spreads were included in this traverse. Single shot holes and multiple-six 20 c.p.s. geophones were used. Geophone groups were centred at intervals of 110 feet along the spread with the individual geophones spaced 22 ft. apart. Shot holes were drilled to about 75 feet and drilling was comparatively rapid. Forty to fifty feet of alluvium was penetrated in each hole before shales of the Roma (?) formation were encountered.

Traverse B - On Roma (?) Formation and Blythesdale Group.

On 4th. June recording commenced on traverse B, which was surveyed from a point immediately south of Surat township (S.P. 9) in a south-easterly direction to S.P.34. This traverse was intended to test shooting conditions on both the Roma formation and the Blythesdale group. However, it now seems likely (see final paragraph under Geology) that what was originally described as Roma formation should probably be assigned to the upper (marine) part of the Blythesdale group. As on traverse A, single shot holes and multiple-six geophones were used. Holes were drilled to about 80 feet.

Traverse C - On Tertiary Sediments south of the supposed axis.

On 18th. June shooting commenced on a reflection traverse approximately 5 miles south of the supposed axis of the Weribone Uplift. Two miles of traverse were shot from SP 37 at the southern end to SP45. Drilling and shooting conditions were again similar to traverse A.

Traverse D - On Tertiary Sediments north of the supposed axis.

On 25th. June 5 holes were shot along the Warroon road about 2 miles north of the supposed axis while waiting for the surveyor to complete the second refraction traverse. This traverse site was chosen because of the large gap existing between the southern end of traverse B and the supposed structural axis.

Refraction Traverse AA.

The main portion of refraction traverse AA was located on a fairly straight stretch of 7 miles on the Surat-Condamine road northeast of Surat (refer to Plate 2). Using a one mile spread of geophones, shots were fired at the centre of the spread and at the northeast end. Multiple-six 20 c.p.s. geophones were used to record reflections as well as refractions. The shot to geophone distance was then increased by intervals of one mile, the shot points being moved towards the northeast while the geophones were gradually moved further to the southwest in order to record from the same section of sub-surface. 6 c.p.s. geophones, connected in pairs, were used to record refractions from distances of a mile or more.

This work was carried out between 21st. and 24th. June. Near the end of the survey another refraction shot was recorded along this traverse with the shot point located 4 miles to the S.W. of the geophone spread.

Refraction Traverse BB.

Refraction traverse BB was surveyed as near as possible along the supposed axis of the Weribone Uplift (Plate 2). Shots were fired from both ends of the traverse with the shot-geophone distance 4 to 5 miles. At the end of the survey a further refraction shot was recorded along this traverse from a shot point offset 5 to 6 miles west of the geophone spread.

5. REDUCTION OF RESULTS.

Treatment of Reflection Results.

In general the number of reflections on each record and their quality and dip were such as to permit the use of the correlation method of cross-section plotting. For this purpose it was not necessary to determine weathering corrections for every recording trace but it was sufficient to calculate this correction at each shot point. In addition, end trace times were corrected to remove the spread correction and all reflection times were corrected to a datum of 700 feet above sea-level. All reflections recorded were picked and each cycle timed and plotted. The reflections were graded according to the system suggested by Gaby (1947) both for the certainty that the event picked was a reflection and for the accuracy of the calculated dip.

To convert the corrected reflection times to depth it was necessary to determine an appropriate velocity function. This was done by the conventional T - ΔT analysis method using the records from the first reflection traverse. Since the total number of reflections from this short traverse were too few to yield an accurate velocity distribution, the results were compared with those obtained by Dooley (1954) at Roma. A 20% reduction of velocity was assumed at Surat from a comparison of the first break velocities recorded there with those recorded at Roma. From this data a velocity-depth curve was obtained, and a time-depth scale constructed for use in plotting the cross-sections. Subsequently, at the end of the survey, a complete T - ΔT analysis was made using all the records. When the results of this were compared with the original velocity function it showed very close agreement down to a depth of 4000 feet. Below 4000 feet the original velocities appear to be too low, resulting in an error of about 800 feet at a depth of 8000 feet. So that the true depth of any point on the cross-section can be readily obtained a corrected depth scale has been drawn on the section alongside the scale used for plotting the section.

Since the reflections are quite numerous and the dips generally very small, it is difficult to gain a clear impression of the overall structural attitude without making a fairly detailed examination of the cross-section. In an attempt to overcome this difficulty two "phantom" horizons have been drawn on the section. These are based for the most part on continuous correlation. Starting at SP 1 with reflection at times of .848 sec. (Phantom A) and 1.244 sec. (Phantom B), these reflections were followed from shot point to shot point as far as these particular events could be correlated with reasonable certainty. When the continuity of these events became questionable, another event showing reliable continuity, and as far as possible within a zone 500 feet above or below the phantom, was chosen. The dip obtained from the correlation of this new event was then used to continue the phantom across the corresponding sequence of shot points. This process was continued along each traverse.

Treatment of Refraction Results.

In most cases the time of the first refraction break could be read with reasonable accuracy. In some cases however, the energy was too weak to produce readable first breaks, and in such cases times were read for the 'first trough' or 'first peak' following the breaks and a correction applied to reduce these time to equivalent 'first break' times.

Corrections were made for the elevation of each shot and each geophone by standard methods. Measurements of weathering depth were not made in sufficient detail to provide a weathering correction at individual geophone positions. Instead an average weathering depth was taken for each traverse and a single weathering correction computed and applied to all traces. The constancy of weathering observed over a distance of a mile on the reflection traverses suggests that the probable error for the slope of the T-D curves due to lack of detailed weathering information would be negligible.

When all the necessary corrections had been applied to the observed first-break times the resulting corrected times were plotted against the corresponding shot to geophone distances. For each set of points thus plotted a line representing the best linear fit was determined by the method of least squares. A special least-square circular slide rule was used for this operation. The slopes of these lines then represent the required apparent velocities.

The depth to each refractor was computed in accordance with the simple two layer theory, the velocity of the overburden being taken as the average velocity to the depth of the refractor. This average velocity was obtained from the vertical velocity distribution derived from the ΔT analysis. This necessitated arriving at an approximate depth, for the refractor first, and the method was thus one of 'successive approximation'. In general this procedure was not onerous since two successive substitutions usually produced an acceptable answer.

6. DISCUSSION OF RESULTS.

(i) General Discussion of Reflection Shooting.

As stated in the introduction, the primary object of this survey was to determine a suitable seismic technique which could be used later for a more complete survey of the area. At the start, single shot holes were tried with multiple-six, 20 c.p.s. geophones arranged in line along the spread at 22 foot intervals. This gave such satisfactory results that it seemed unnecessary to try more elaborate techniques. Later, a comparison was made between multiple-six 20 c.p.s. geophones and multiple-ten 6 c.p.s. geophones. The 20 c.p.s. geophones, which have the better characteristics for reflection shooting, produced the better record. Comparative records were also taken at several locations using 9-hole (diamond) shot patterns. A very slight improvement in record quality resulted but the improvement did not justify the additional drilling required.

Most records showed an adequate number of reflections which were distributed fairly evenly in time between about .4 second and 1.4 seconds (see Plate 3a). Although none of the reflections could be correlated along the whole length of traverse, many could be correlated over sections from ¾ to 1 mile in length. For this reason, and because the dips recorded were very small, the correlation method of cross-section plotting was used throughout the survey.

As already noted (Reduction of Results) two "phantom" horizons were drawn on the reflection cross-section (Plate 4). Phantom A is representative of dips near the middle of the sedimentary section (-2900 to -3500 feet) while Phantom B represents dips from the deeper part of the sedimentary section (-5400 to -7200 feet). It is convenient to refer to these two phantom horizons in describing the structure beneath the individual traverses and, later, to estimate the possible overall structure assuming what are considered to be the most likely correlations across the gaps between the traverses. It must be emphasised, however, that these correlations may be in gross error.

Reflection Traverse A.

The results of this traverse are shown on Plate 4. The location of the traverse is shown on the plan on Plate 2. The reflections indicate generally horizontal strata with a small overall south dip component. As measured on phantom A this dip amounts to about 70 ft. per mile, while phantom B shows about 130 ft. per mile.

The tentative correlations shown across the 1.5 mile gap between shot points 8 and 9 are based on the correlation of three groups of reflections that show similar characteristics of elevation and envelope shape across the gap.

Reflection Traverse B.

The results of this traverse are also shown on Plate 4, while the location is given on Plate 2. Again generally horizontal strata are indicated with even less overall change in depth (zero on phantom A, and about 75 feet on phantom B) than was shown on traverse A. There is some indication on this traverse of a small, flat topped, very low relief feature centred about shot points 18 to 23. From shot point 18 to shot point 9 a component of northwest dip is indicated, the relief being about 100 feet on phantom A and 220 feet on phantom B. There is a slight thinning of the sediments over the top of this feature of the order of 120 feet (as measured between the two phantoms). South dip is resumed from SP 23 to SP31. The extension of the phantoms across the gap between Traverse B and Traverse D is based entirely on the tentative correlation of a single deep reflection and is therefore unreliable.

Reflection Traverse D.

Referring again to Plate 4, this short traverse is featureless, essentially flat dips prevailing throughout. Correlation of the phantoms from this traverse to traverse C is again unreliable being based on the character of a single deep reflection.

Reflection Traverse C.

The results of this traverse, and its location are shown on Plates 4 and 2 respectively. On this traverse reflections from above 6000 feet are flat from SP 45 to SP 41 and then deepen to the south by about 250 feet from SP 41 to SP 47. Below 6000 feet some erratic dips are noticed suggesting a possible disconformity at this depth. Such a disconformity is not apparent on the other traverses.

Phantom B shows south dip from SP 45 to SP 42. A slight (40 ft.) reversal of dip is indicated from SP. 42 to SP. 40; south dip is then resumed from SP. 40 to SP. 37. This phantom horizon shows an overall deepening to the south of about 660 ft. from SP 45 to SP 37.

The distribution and density of reflections on these four traverses suggests a fairly uniform section of Mesozoic and, possibly, Permian sediments varying in-thickness from 7000 feet along Traverse A to about 8000 feet along Traverse C. As will be seen later, this is in fair agreement with the refraction results.

It will be noted that quite a few events have been plotted at depths considerably greater than those mentioned above. These events in all cases are of weak energy and without character, and their origin is uncertain. Some may be multiple reflections, though they cannot be identified as such under the prevailing conditions of flat dips and approximately constant shot depth. Others may possibly be the result of accidental 'line-up' of noise. Nevertheless the possibility cannot be excluded that some of these events may be bona fide reflections from within a Palaeozoic section.

(ii) Discussion of Refraction Results.

Limitations of time and explosive precluded thorough shooting on the two refraction traverses. It was not possible to fire a number of essential shots. Traverse AA, northeast of Surat, was shot more completely than Traverse BB. However, since the interpretation of the results of Traverse AA are dependent upon the results of Traverse BB, it is convenient to discuss this latter traverse first.

Refraction Traverse BB.

The time-distance curves for this traverse are shown on Plate 6. First breaks recorded from shot points 78 and 96 gave apparent velocities of 13,625 and 13,380 feet/sec. respectively. Comparison of 'reciprocal intercept' times shows that these two velocities are actually 'up' and 'down-dip' measurements along the same refractor (named V4). This then gives a true velocity of 13,500 ft/sec. and a depth of -3400 feet. It is further indicated that this refractor has a westerly dip component of less than 1 degree (actually computed as 0°57').

From shot point 78A a velocity of 18,900 ft/sec. was obtained. This is believed to be a basement velocity (V5), and, assuming this refractor to have a dip of less than 1° (as for V4), would be approximately a true velocity. On this assumption, the depth to the high velocity refractor is computed as -7200 feet, which is in fair agreement with the thickness of Mesozoic and Permian sediments deduced from the reflection section.

Near the end of the spreads shot from SPs 78 and 96 breaks were obtained which show an apparent velocity intermediate between V4 and V5. It is considered that these breaks result from interference between the 'waves' which, having travelled along the V4 and V5 refractors, arrive more or less together within a zone near the critical distance, and they have therefore been disregarded in the final analysis.

Refraction Traverse AA.

The time-distance curves for this traverse are shown on Plate 5. Velocities from five principal refractors are assumed to have been recorded. Examining the time-distance curves from SP 68 and SP 127, the 'reciprocal intercept' times indicate that these two velocities have been measured along the same refractor. Computation then shows that this refractor has a true velocity of 13,200 ft/sec. and is at a depth of -3300 feet, and consequently is correlative with the V4 refractor on Traverse BB. A southwesterly dip component of 0°58' is calculated for this refractor and it has been assumed from this that the shallower refractors (V1, V2 and V3) have negligible dip and that the velocities recorded are, for all practical purposes, true velocities.

It is now necessary to consider the velocities of 22,000 and 21,900 ft/sec. recorded respectively from SPs 72 and 75. These most likely represent a basement velocity (V5). It is rare to find basement velocities exceeding 19,000 f/s and the velocity recorded on Traverse BB is consistent with this. It seems reasonable to assume therefore that the higher velocity recorded on Traverse AA represents an 'up-dip' measurement. Accepting these assumptions, the dip of the V5 refractor (i.e. basement) is computed to be 4°50' to the northeast, and the mean depth is -6300 feet.

The general results of the refraction work are summarised in the table below:-

Refractor	Traverse AA.			Traverse BB.		
	Velocity.	Depth (w.r. to sea level	Dip.	Velocity.	Depth.	Dip.
Sub-weathering V1	6600f/s	(67ft.) ⁎	Assumed flat	6400	(80ft.)⁎	
V2	[illegible]	+ 300ft	Assumed flat			
V3	10,100	- 500ft	Assumed flat			
V4	13,200	-3,300	0°58' S.W.	13,500	-3,400	0°57'W
Basement V5	18,900	-6,300	4°50' N.E.	18,900	- 7,200	Assumed flat.

⁎ mean depth below surface.

From a knowledge of velocities measured by the Bureau, the three refractors identified above as V1, V2 and V3 may be assumed to be within the Mesozoic section. The velocity measured for the V4 refractor (13,200-13,500 f/s) is compatable with velocities obtained for Permian sediments and a tentative identification as such seems reasonable. The results indicate therefore that in the region of Traverse AA there exists a probable Mosozoic section of about 4000 ft. thickness, underlain by about 3000 ft. of sediments of possible Permian age. As already stated, the velocity determined for the V5 refractor is compatable with a basement velocity. At the same time it must be recognised that such a velocity could also be obtained from a Palaeozoic limestone. However, the presence of such limestone has not been established in this part of the basin, whereas basement rocks have been definitely identified in some of the bores near Roma. It seems most likely therefore that the V5 refractor does in fact represent basement.

The results deduced from Traverse AA indicate that, over the limited distance covered by the measurements (approx. 1 mile), the V4 and V5 refractors are not conformable. Objection may therefore be made to the previous assunption that they are conformable (to the extent that basement is assumed flat) along traverse BB. It may be well therefore to consider the effect on the deductions of assuming that the basement is not flat along this traverse. If the basement dip is not flat along Traverse BB then it will most likely have a westerly component, since the velocity recorded from SP 78A is considered to be too high to be a 'down-dip' velocity. The true basement velocity would then be less than 18,900 ft/sec. and the computed angle of dip on Traverse AA would be increased. The computed depth to basement on both traverses would be increased by an amount inversely proportioned to the cosine of the angle of dip.

Thus, the general interpretations already made would not be affected qualitatively and the change in the amount of dip would probably be small.

The above results indicate a probable northeast component of dip, at basement, along Traverse AA, and a northeasterly thickening of the deeper sediments (as indicated by the dip of V4 and V5). This divergence is also apparent on a single reflection record taken at shot point 60 (see Plate 3b).

The depths computed for the V4 and V5 refractors represent average dips to the south of 4 ft. and 39 ft. per mile respectively between traverse AA and traverse BB.

Referring again to the reflection section, if the steeper dips shown at the south end of traverse C are omitted, the two phantom horizons, as drawn, show average dips to the south of about 8 ft. per mile (Phantom A) and 22 ft. per mile (Phantom B).

The effective depth of phantom A is close to, but slightly less than, the depth to the V4 refractor, while phantom B is probably about 500 ft. above V5 (basement).

The dips indicated by the reflection and refraction work therefore, appear to be in fair agreement and together indicate a significant departure from the figure of 80 ft. per mile quoted by Reeves (1947) for the regional rate of dip near Roma.

7. CONCLUSIONS.

The seismic work in the Surat area, though of limited extent, demonstrated that conventional methods of seismic reflection and refraction shooting could be used successfully throughout the area, and that the application of both methods would be useful in testing geological structure. An extensive and detailed survey comprising both reflection and refraction shooting could be expected to yield much useful information on the thickness of Mesozoic sediments and, possibly, on the thickness and extent of any underlying Palaeozoics. It should be possible to determine if any uplift exists within the area, and if it does, whether or not some formations are missing along the crest of the structure that otherwise exist along the flanks. If a structure is present, detailed reflection work should determine its culmination, or indicate an alternative test drilling target, such as a possible stratigraphic trap. Refraction work conducted over the target area should indicate the depth to basement, or otherwise determine the target depth for a stratigraphic bore. Without more knowledge of the nature and extent of any possible structure in the area no attempt can be made to set a time limit for an adequate seismic programme. However, on the presently available evidence 3-4 months might be considered a reasonable minimum estimate.

The survey has provided little or no evidence for the existence of the Weribone Uplift structure as postulated by Jenkins. In the case of a very broad and gentle structure such as that postulated, a basement high might be expected to correspond to the anticlinal axis of the sediments. This has not been borne out by the refraction work assuming that Traverse AA is well clear of any structural high and that there is no synclinal axis between the two refraction traverses (reflection traverses A, B and D suggest that there is not).

Some flattening of the regional dip across the area is indicated, with the possibility of a local anticline of very low relief occurring at a depth of about 6000 ft. near the middle of traverse B.

The evidence, such as it is, of north dip at basement depth on traverse AA raises the possibility of the existence of more extensive northerly dips somewhere north of the existing seismic traverses. This dip however, could be caused by a purely local irregularity in basement topography which would have little structural significance. The checking of this possibly extensive north dip would constitute a valid objective for further seismic work over an area of, say, 10 to 15 miles north from Surat.

8. REFERENCES.

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APPENDIX 'A'.

NOTES ON DRILLING TIMES OF SEISMIC SHOT HOLES.

The following table summarises the drilling time and footage drilled during the Experimental Seismic Survey At Surat, Queensland. The total number of holes drilled includes redrills and also holes for multi-hole shot patterns, 5 of which were shot.

No. of operation shifts 32	equals	272 hrs.
Overtime (Maintenance)	=	33½hrs.
" (Drilling)	=	8½hrs.
Total Overtime	=	41 hrs.
No. of holes drilled	=	112
Total Footage	=	7346 ft.
Drilling Time	=	123½ hrs.
Travelling & Rigging Time	=	99¾ hrs.
Time lost Queen's Birthday (Holiday)	=	8½ hrs.
" " because of rain	=	59½ hrs.
" " pulling casing	=	5 hrs.
" " shifting camp	=	29½ hrs.
" " waiting for water	=	3 hrs.
" " engine repairs	=	6½ hrs.
" " pulling out bogged trucks	=	20 hrs.
" " rig repairs	=	26¼ hrs.
Average depth of hole	=	65 ft.
Deepest hole	=	138 ft.
Bentonite used	=	2 bags.

APPENDIX 'B'.

Comments on A.O.G. Gravity survey in Surat Area.

The results of the A.O.G. gravity survey in the Surat area have been made available since this report was written and are discussed here very briefly. The results indicate several local anomalies, both positive and negative, of relatively small areal extent but showing quite steep gradients. Quite clearly these gravity anomalies cannot be correlated with structural relief, either of the basement rocks or within the sedimentary section, both of which have been shown by the seismic results to be essentially flat.

It must be assumed therefore that, within the Surat sub-basin, a gravity survey is of no value in determining target areas for further seismic work.

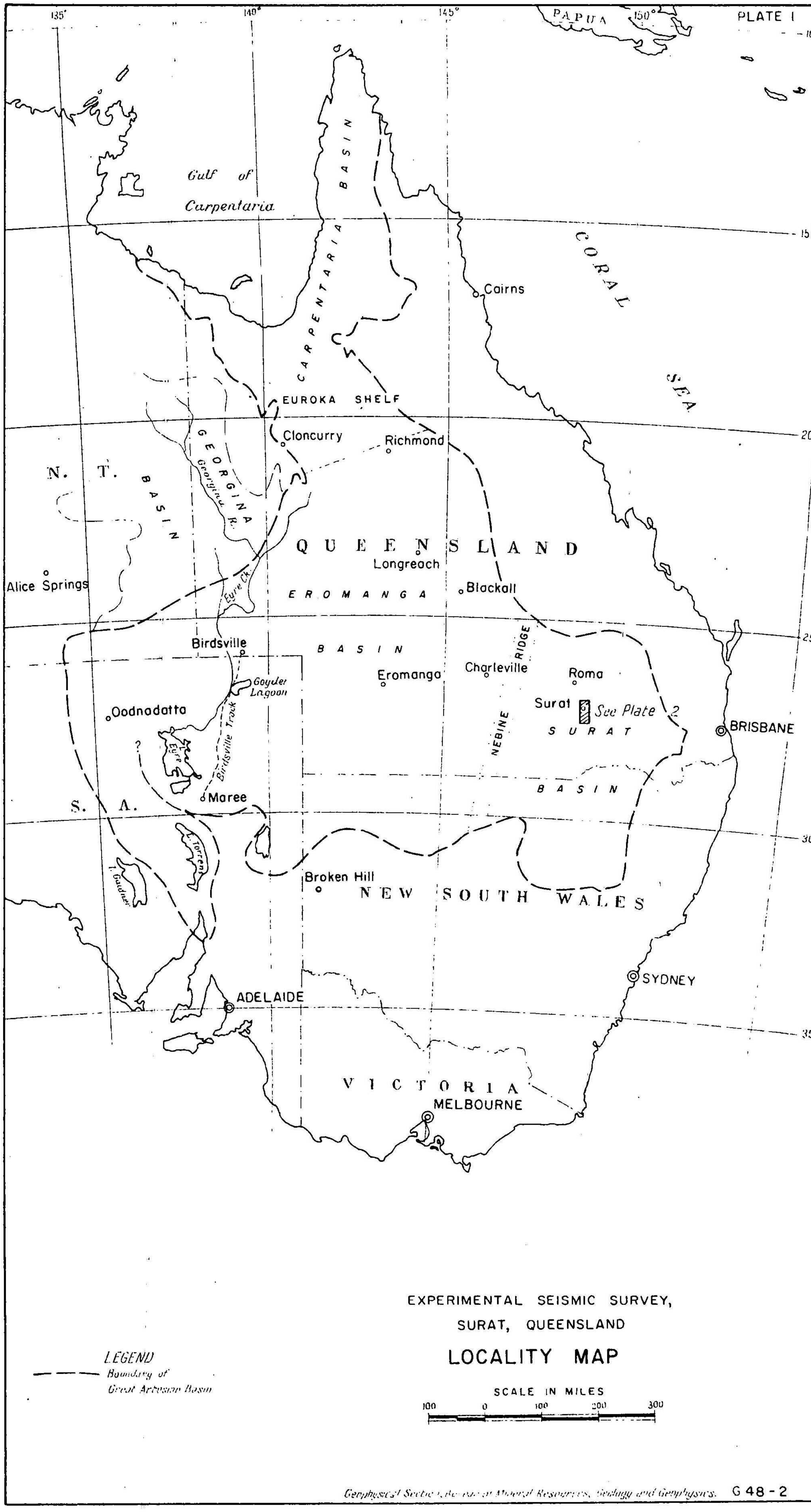

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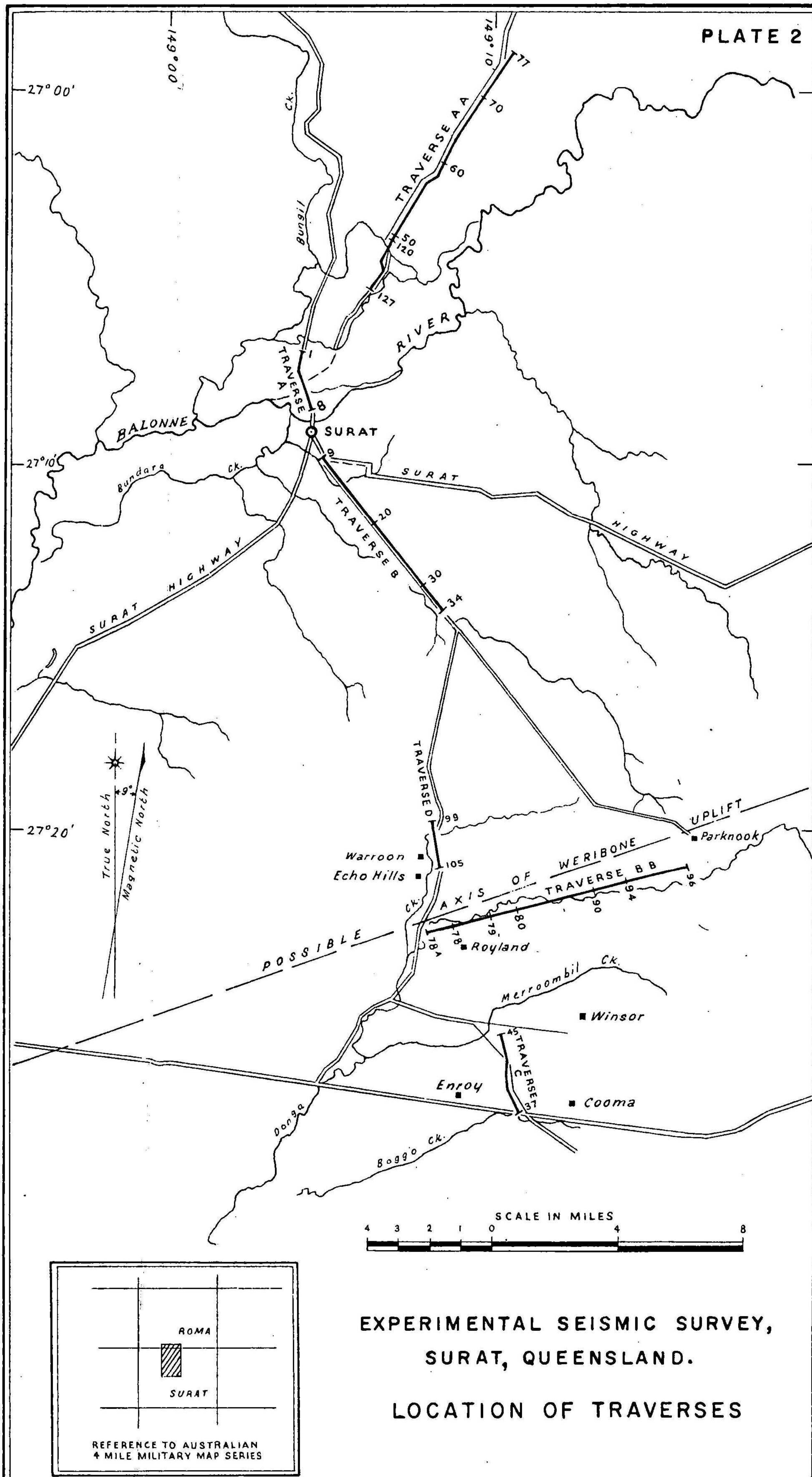
PLATE 2



EXPERIMENTAL SEISMIC SURVEY,
SURAT, QUEENSLAND.

LOCATION OF TRAVERSES

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics   G 48-6

(TO ACCOMPANY RECORDS 1959, NO. 13)

PLATE 3

BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS.
SEIMIC SURVEY.

Area SURAT Trav. B
S.P. 13 Date 5/6/58
Shot 2B Charge 6 lbs Depth 60/62
Spread No1 - 1320' SE/No 24 - 1320' NW
Gain MAX. Filters L22 H33
Mixing S Presup 40% A.
Geo. TIC 20 Amp. TIC 621 Cam. TIC 10"

PATTERN GEOPHONES

No. 6 per trace Spacing 22'
Layout IN LINE.

PATTERN HOLES

No. .... Spacing ....
Layout .... Charge ....
Remarks.

ELEVATION AND WEATHERING CORRECTIONS

D = 2__ Ve = 7000 dS = 6/ E-dS/Ve = [illegible]

	Trace	Dist	Elev	t w	ft w	E, Ve	Σt
SE SP 14	1	1320	813				
	2		816				
	3		814				
	4		813				
	5		811				
	6		803				
	7		807				
	8		804				
	9		802				
	10		798				
	11		793				
	12	110	789				
SP 13.		00	793				
	13	110	794				
	14		798				
	15		798				
	16		800				
	17		801				
	18		802				
	19		804				
	20		806				
	21		807				
	22		805				
	23		809				
N.W. SP 12	24	1320	808				

	LS Elev	LS t w	LS ft w	LS E, Ve	LS Σt
Traces 1-12					
13-24					
1-24					

PLATE 3a

BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS.
SEIMIC SURVEY.

Area SURAT Trav. AA
S.P. 60 Date 1-7-58
Shot 4A Charge 10 Depth 90/94
Spread No1 - NE No 24 - SW
Gains Max Filters L22 H33
Mixing .... Presup .... AGC ....
Geos .... Amp .... Cam ....

PATTERN GEOPHONES

No. 6 Spacing 22'
Layout IN LINE

PATTERN HOLES

No. .... Spacing ....
Layout .... Charge ....
Remarks.

ELEVATION AND WEATHERING CORRECTIONS

D = ____ Ve = ____ dS = ____ E-dS/Ve = ____

	Trace	Dist	Elev	t w	ft w	E Ve	Σt
SP 61	1		855				
SP 60			846				
SP 59			833				

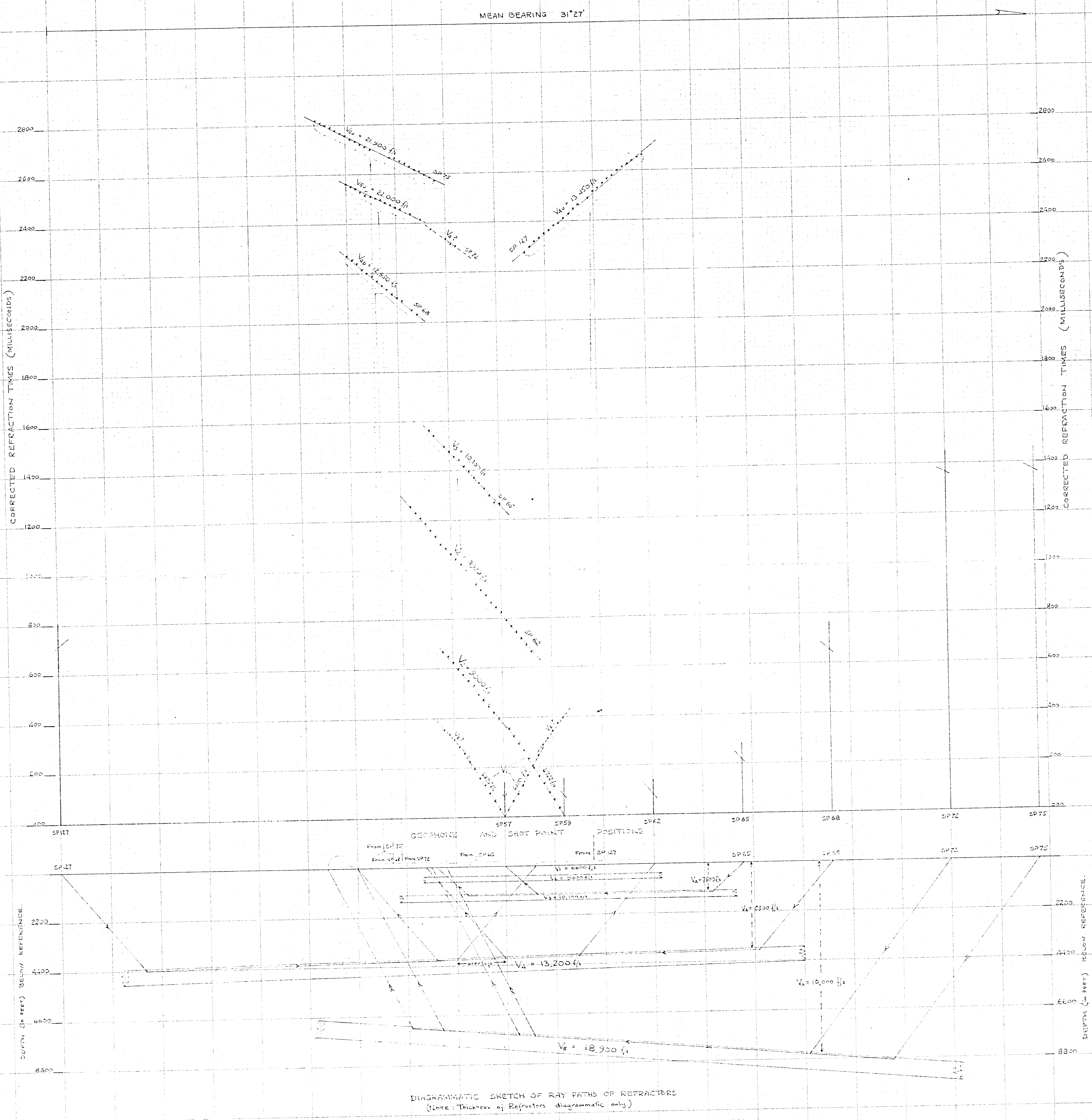
Traces 1-12
13-24

PLATE 3b

BEARINGS SHOWN ARE MAGNETIC
(DECLINATION 8°30' E)
REFERENCE PLANE (+700 ft a.s.l.)
REVISED DEPTH SCALE
DEPTH in feet BELOW REF.
172°
155°
139°
157°
1.5 mls.
135°
145°
135°
SP1 SP2 SP3 SP4 SP5 SP6 SP7 SP8
SP9 SP10 SP11 SP12 SP13 SP14 SP15 SP16 SP17 SP18 SP19 SP20 SP21 SP22 SP23 SP24
Phantom A
Phantom B
TRAVERSE A
TRAVERSE B
SURFACE ELEVATION
WEATHERED LAYER
SHOT DEPTH
REF. PLANE
"FIRST BREAK" VELOCITIES (ft/sec)
6760 7000 6800 6880 6870 6870 7080 6050 8100 7330
6970 7050 7160 7430 7050 7050 7160 7160 7050 6800 6880 6980 5620 9425 5850 8980 7760 7500 7810
SHOT HOLE LOGS
(interpreted by Dr. T.B. Jenkins)


PLATE 4
BEARINGS SHOWN ARE MAGNETIC
(DECLINATION 8°30'E)
DEPTH in feet BELOW REF.
REVISED DEPTH SCALE
Phantom A
Phantom B
TRAVERSE D
TRAVERSE C
SURFACE ELEVATION
WEATHERED LAYER
SHOT DEPTH
REF. PLANE
"FIRST BREAK" VELOCITIES (ft/sec)
SHOT HOLE LOGS
EXPERIMENTAL SEISMIC SURVEY,
SURAT, QUEENSLAND
REFLECTION CROSS-SECTION
HORIZONTAL AND VERTICAL SCALES IN FEET
G48-5

PLATE 5



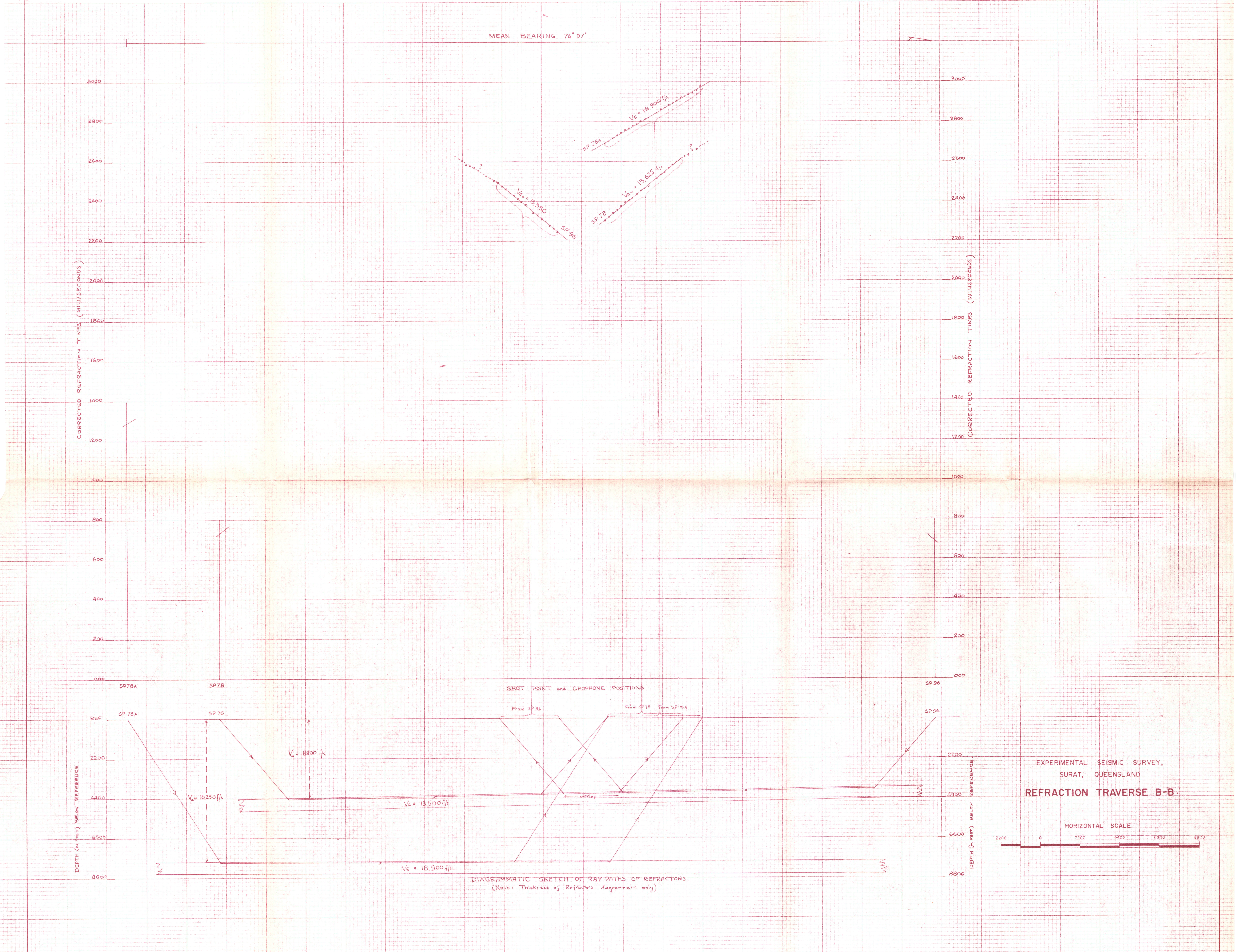
EXPERIMENTAL SEISMIC SURVEY,
SURAT, QUEENSLAND

REFRACTION TRAVERSE A-A

HORIZONTAL SCALE

G 48-3

PLATE 6



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G 48-4

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