COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

RECORDS 1960 No. 49

LA GRANGE, SEISMIC REFLECTION SURVEY, W.A. 1955

by

E.R. Smith

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ABSTRACT.

A seismic reflection survey was conducted by the Bureau of Mineral Resources during 1955, in the La Grange area of Western Australia. The object of the survey was to investigate the sedimentary development of the Canning Basin south of the Fenton Fault.

A sedimentary section of at least 4,400 feet, and possibly as much as 7,000 to 8,000 feet was indicated. Although no evidence of an angular unconformity was obtained, there is probably a change in the type of sedimentation at 2,760 feet.

1. INTRODUCTION.

During September of 1955, the seismic party of the Bureau of Mineral Resources conducted a seismic reflection survey in the La Grange area of Western Australia. This was part of a general reconnaissance programme undertaken by the Bureau in the Canning Basin during 1955. Other surveys were conducted at Christmas Creek, Barnes Flow, Langey Crossing and Broome. The object of the La Grange survey was to investigate the development of the Canning Basin south of the Fenton Fault, where little information is available from surface geology.

La Grange is situated on the north-west coast of Australia, approximately 60 miles south-west of Broome. There is a telegraph relay station and a native mission on its shores at latitude 18° 42' and longitude 121° 46' (plate 1). The Great Northern Highway, connecting Perth to Darwin passes the telegraph station. In this vicinity it is a two-wheel track crossing alternately elevated sandy stretches and low-lying black soil plains. The plains are impassable after rains or during the exceptionally high spring and autumn tides. The sandy ridges are covered with thick scrub and timber and the plains with low grasses.

The coastal strip is occupied by a cattle station (Thangoo) to the north of La Grange, and a sheep station (Frasier Downs) to the south, the grazing areas extending only 5 to 10 miles inland. The Canning Desert lies beyond this coastal strip.

The party's camp was situated about ¼ mile north of the telegraph station, and the main traverse (A) extended along the road from 2½ miles south-west of the station to 10 miles north-east of it. There were also two short cross traverses - traverse B, ¾ mile in length crossing A near shot point 3, and C, 2 miles in length crossing A at shot point 29 (plate 2).

Details of personnel, equipment and field operations are set out in appendices to this report.

2. GEOLOGY.

The Canning Basin covers an enormous area of the north-west of Australia. Along the coast, it extends from 50 miles north-east of Port Hedland to 50 miles north of Derby, and inland to as far as the Northern Territory border. The north-eastern section is generally referred to as the Fitzroy Basin, which is known to contain considerable thicknesses of Palaeozoic rocks, both from outcrop and bore information. The geology of the Fitzroy Basin is discussed fully by Guppy and others (1958).

The south-western margin of the Fitzroy Basin is defined as the Fenton Fault, which runs in a north-west south-east direction south of the Fitzroy River. At least along a considerable portion of this fault, it is known to have a large downthrow, of the order of 10,000 feet, on its north-eastern side. (Vale and Smith 1959). To the south of the Fenton Fault, the country is mostly sand-covered, with rock outcrops both rare and poor. It is also difficult country to penetrate, because of the arid conditions prevailing and the difficulty of traversing the sand-dunes in normal vehicles. Hence geological information in this area is rather scanty. Because of the large throw of the Fenton Fault and its apparent regional significance, it had generally been assumed that the basement over most of the southern part of the Canning Basin was relatively shallow, with a thin Permian section covering a large portion of it.

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On the western side of the Basin, Mesozoic sediments are known to crop out in Dampier Land, the Edgar Ranges, and along the Coast. Fossils 2½ miles south of the La Grange telegraph station have been placed as of Upper Jurassic or Lower Cretaceous age. (Dickins, 1956).

The geology of the Basin is not of much assistance in selecting a suitable area to conduct a short reconnaissance seismic survey aimed at investigating the sedimentary development south of the Fenton Fault. From the point of view of access, the survey was best confined to the coast between Port Hedland and Broome. Gravity work carried out by the Robert H. Ray Company on behalf of West Australian Petroleum Ltd., suggested that the La Grange area might be the deepest part of the Basin along this coastal strip. Hence this area was chosen for the seismic survey.

Since the survey was conducted, West Australian Petroleum have drilled several bores on the south side of the Fenton Fault. These bores have proved the existance of several thousands of feet of Mesozoic and Palaeozoic s ediments in various parts of this section of the Basin. This work is as yet unpublished.

3. RESULTS.

Near Surface Conditions.

The velocity of the near surface formations are listed below.

		Velocity	DEPTH SURFACE
First Weathering Layer	:	1,600 ft/sec.	Surface
Second " "	:	3,500 ft/sec.	10 to 20 feet.
Sub-weathering "	:	10,000 ft/sec.	35 to 45 feet.

The base of the first layer coincided with an excellent water table at approximately 10 feet on the black soil plains. Traverse A crossed these plains from shot points 17 to 38 and from 39 to 50. Along these sections, it was difficult to keep the holes open below this depth, as sand and gravel were continually washed into the hole from the water table. The best quality records were obtained by placing the charges about 10 feet below the water table.

From shot point 1 to 16, traverse A crossed a sand ridge which averaged about 20 to 30 feet higher elevation than the plains. There was no significant water table here and both weathering layers were thicker. It was found best to place the charge below the second layer along this section of the traverse.

A sub-weathering velocity of 10,000 ft./sec. is surprisingly high for a Mesozoic section, and in fact the average vertical velocity calculated from the reflections was only 7,650 ft./sec. (see below). It is likely that this high sub-weathering velocity is due to thin limestone bands close to the base of the weathering. The drillers reported encountering limestone or limestone bands in most shot holes.

...3/.

Vertical Velocity :

A $(t - \Delta t)$ analysis was made of the reflections recorded in the area in order to calculate a velocity distribution for the sedimentary section. The slopes of the reflections across each half of the geophone spread were calculated using a least square method. These were corrected for weathering and elevation differentials and averaged with adjacent reflections from the same horizon to eliminate any slope due to the dip of the horizon. These final values, which should represent the time differential across half the geophone spread due to shot point-geophone distances only, were plotted against the reflection time t_o, as shown on plate 3.

The plot of Δt versus t_o shows the points to fall mostly in groups at average times of t_o = .32, .57, .72, .88 and 1.01 seconds. This reflects the correlation which is possible with some reflections in the La Grange area. The reflection times and time differentials were averaged in groups and the curve shown fitted to these average points. In calculating average and interval velocities from this curve, the Δt's corresponding to the times of the main groups set out above were used, as these were the points on the curve which were best controlled. The average and interval velocities calculated are shown on plate 4.

The largest group of points at .72 seconds in the $t - \Delta t$ analysis correspond to a very strong reflection which can be correlated throughout the traverses. The average velocity above this reflection horizon is 7,650 ft./sec., and the interval velocity ranges from 7,000 ft./sec. to 9,000 ft./sec. The velocity below the horizon increases sharply to 11,700 ft./sec. It is likely that this horizon which is at an average depth of 2,760 feet, corresponds to a major break in the type of sediments in this area.

West Australian Petroleum have since shot a refraction profile in the La Grange area located about 8 miles south of Traverse A. (Scott, 1957). This confirmed the sharp increase in velocity. Refractors of 10,830 ft./sec. and 15,200 ft./sec. were recorded with the depth of the 15,200 ft./sec. refractor computed as 2,750 feet. This checks very well with the depth obtained from the $t - \Delta t$ analysis.

Reflection Cross-sections :

The quality of the records obtained in the area was in general fair to good. One reflection in particular, at .7 seconds was of very good quality and could be correlated almost throughout the area. Other reflections could be correlated across several shot points in some places, notably the one at 1.0 seconds in the northern part of the area. However, it is noticeable from the plotted cross-sections (plates 5 and 6) that the reflections are more numerous and persistent at the two ends of traverse A than they are in the central area. This poorer reflection zone corresponds approximately with the elevated sandy country between shot points 1 to 16, where, as has been reported above, surface shooting conditions are very different from those existing on the plains. It is most likely these varying surface conditions which are responsible for the change in the reflection section. The apparent change in the reflection section does not suggest any structural or lithological change in the sedimentary section.

.../4.

In estimating the depth of the sedimentary section from a reflection cross-section, it is always necessary to watch for the possible existence of multiple reflections. In this area this is especially the case for conditions are suitable for the recording of multiple reflections. In the first place there is a strong reflector at a shallow depth (2,760') and secondly on the black soil plains there is an excellent water table to reflect the energy back down again. It is across these plains that the deeper reflections are recorded consistently. The most persistent reflection deeper than the horizon at 2,760' is the reflection at 1.0 seconds or 4,400' at the northern end of traverse A and along traverse C. It is unlikely that this is a multiple for the following reasons :-

(a) Its reflection time (average 1.0 seconds) is not a multiple of the time of the strong reflection (.7 seconds). Neither is it considered likely to be a multiple involving the main reflecting horizon and a shallower one. The obvious shallower reflection would be at .55 seconds.

(b) The vertical velocity calculated from the t - Δt analysis, in which this reflection was used, shows a marked increase below the main reflection horizon at 2,760 feet. If the reflection was a multiple, then a velocity of the order of that above the main horizon would have resulted.

(c) Northwards from shot point 31 on traverse A, the main reflection deteriorates to poor quality and actually disappears on some records, but the reflection at 1.0 second continues at quite fair quality.

It seems that a sedimentary section of 4,400 feet can be confidently predicted. Further scattered reflections recorded below this depth could mean that the section is of the order of 7,000 to 8,000 feet. The absence of reflections below this depth can not be taken as necessarily meaning that the sedimentary section is not deeper.

A very gentle structural picture is presented by the reflection cross-sections. The main reflecting horizon indicates a shallow asymmetric syncline at the northern end of traverse A with its axis near shot point 27. The southern flank dips at approximately 50 feet per mile and its northern flank at 150 feet per mile. This horizon is flat along the southern part of traverse A from shot point 11 to 49. There is however an interruption in its continuity at shot point 42, which is probably due to a fault. A further break in its continuity at S.P. 8 is due to a bad record caused by shooting too shallow. The partial disappearance of this reflection at the northern end of the traverse is not explained.

The other reflections appear to be conformable with this horizon. The most definite dip shown by them is the south dip of 150 feet per mile indicated by the reflection at 4,400 feet, at the northern end of traverse A.

Traverse B indicates slight dip to the north-west (towards the coast) and traverse C slight dip to the east (inland).

.../5.

4. CONCLUSIONS.

(1) The depth of sediments is at least 4,400 feet and may be 7,000 to 8,000 feet or more.

(2) There is no evidence of any marked angular unconformity in the section. However, the strong reflecting horizon at 2,760 feet probably represents a major change in the type of sediments.

(3) There ~~was~~ were no major structural features crossed by the traverses. There is a gentle asymmetric syncline with its axis at about shot point 27 and probably a small fault at shot point 42.

5. REFERENCES.

DICKENS, J.M.	1956	:	Minute to Chief Geologist, Bureau of Mineral Resources (unpub.).
GUPPY, D.J., LINDNER, A.W., RATTIGAN, J.H. and CASEY, J.N.	1958	:	Geology of the Fitzroy Basin, W.A. Bur. Min. Resour. Aust. Bull. 36.
SCOTT, D.H.	1957	:	Letter from Exploration Manager West Australian Petroleum Co. to Chief Geophysicist, Bureau of Min. Resources (unpub.).
VALE, K.R. and SMITH, E.R.	1959	:	A Seismic Investigation of the Fenton Fault at Barnes Flow, Canning-Fitzroy Basins, Kimberley Division, W.A. Bur. Min. Resour. Aust. Rec. 1959/63.

APPENDIX.

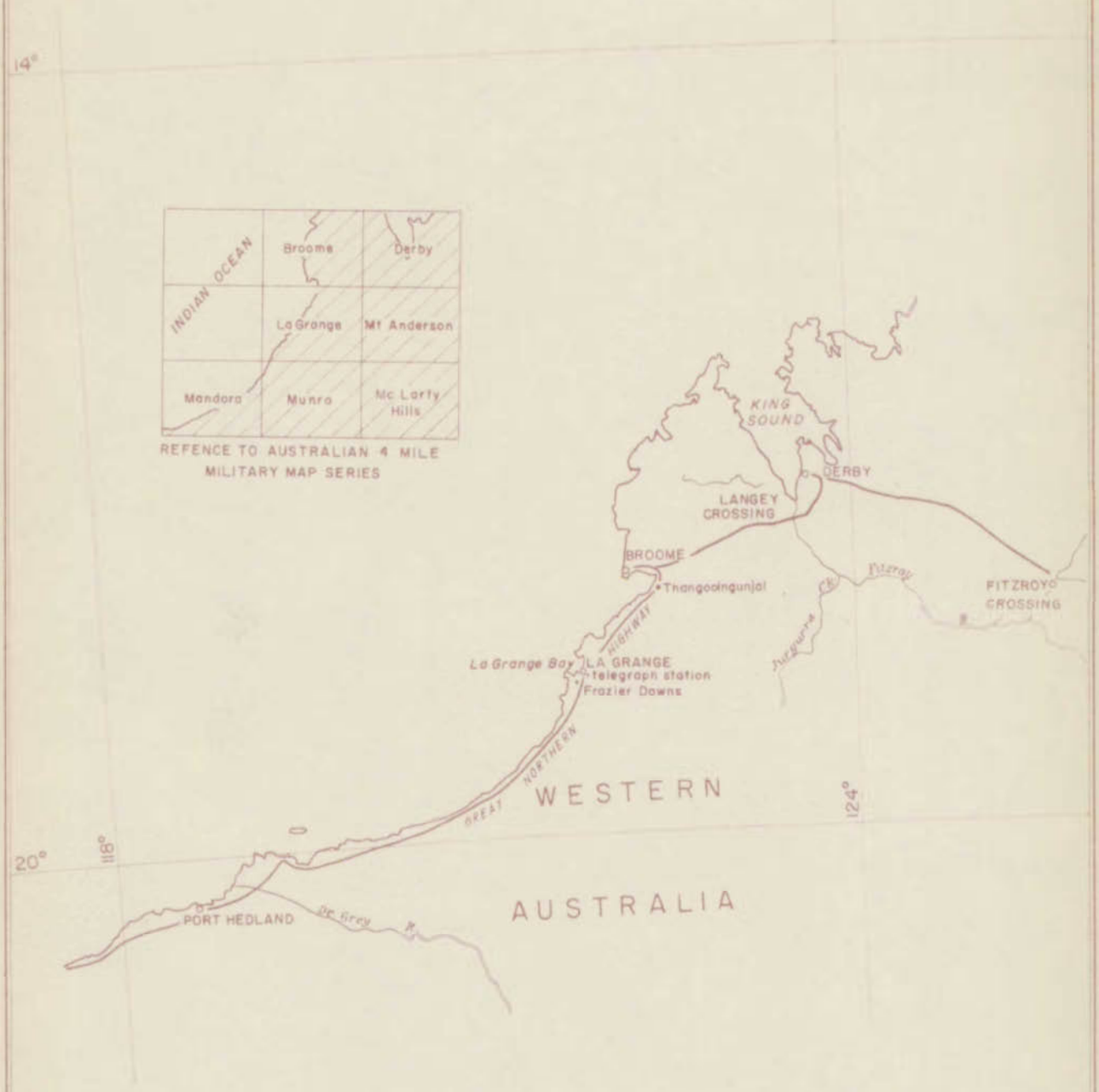
(a) Field Party Set-up.

Party Leader	:	E.R. Smith
Other Geo-physicists	:	M.J. Goodspeed
Other Staff	:	Surveyor, 2 chainmen, observer (radio technician), shooter, 2 drillers, 2 drill assistants, 2 mechanics, cook, cook's offsider, 7 field hands.
Recording Equipment	:	Technical Instrument Company, 24 channel portable seismograph, type 521, and geophones.
Drill Equipment	:	2 Failing "750" drilling rigs.
Vehicles	:	International utility, 4 Land Rovers, 2 Morris-Commercial, 4 x 4 one-ton Trucks, 8 Commer, 4 x 4, three-ton Trucks.

(b) Field Data.

Date Commenced	:	5th September, 1955.
Date Completed	:	25th September, 1955.
Shot Point Interval	:	1,320 feet.
No. of Geophones	:	4 per trace
Geophone Spacing	:	5 feet.
No. of holes shot	:	60.
Total hole drilled	:	3,299 feet.
No. of Shooting Days	:	11
Average holes shot per day	:	$5\frac{1}{2}$.

PLATE 1



REFENCE TO AUSTRALIAN 4 MILE MILITARY MAP SERIES

SEISMIC REFLECTION SURVEY NEAR LA GRANGE,
KIMBERLEY DIVISION, W. AUSTRALIA

LOCALITY MAP

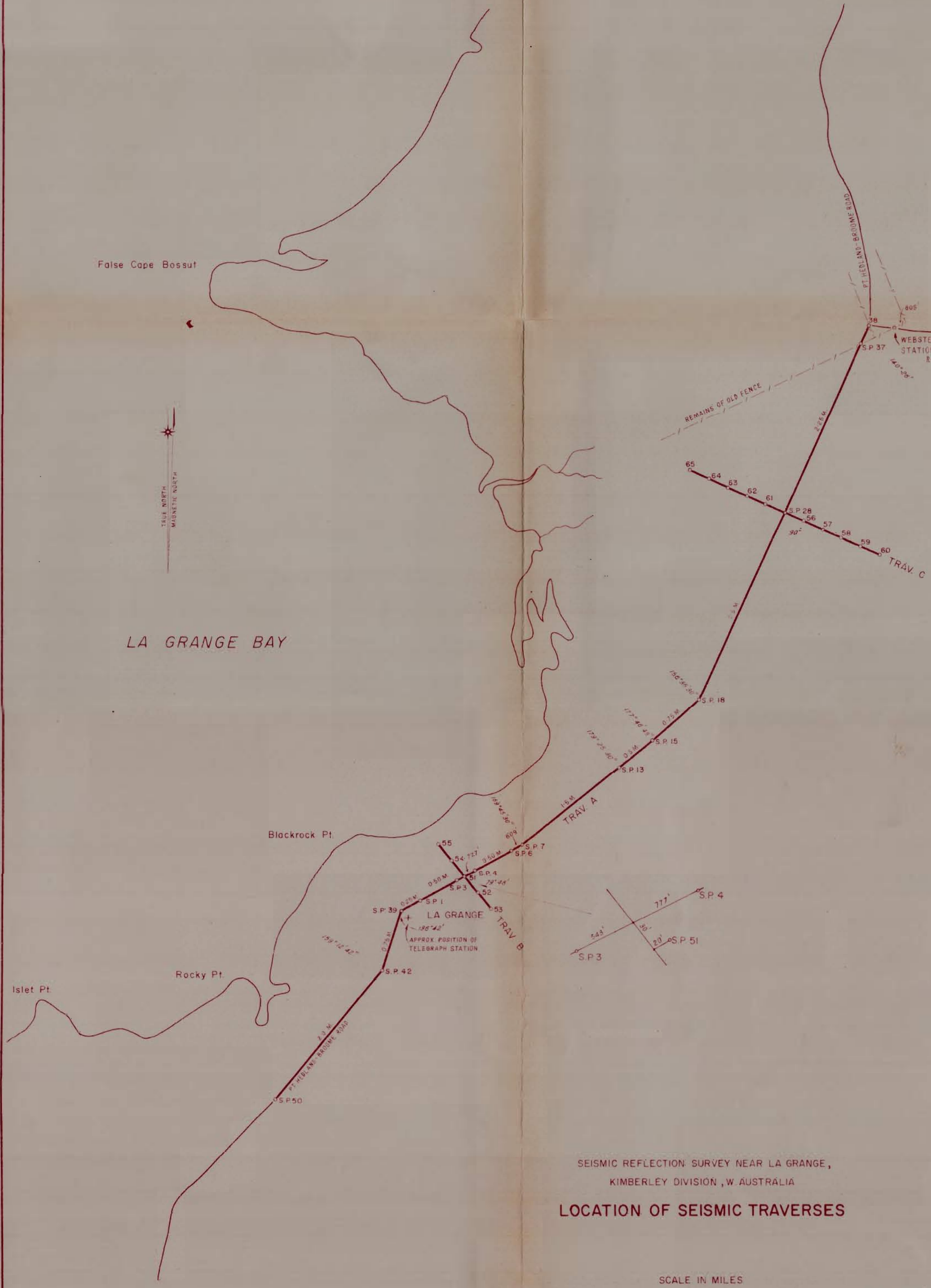
SCALE IN MILES

50 0 50 100 150 200 250

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G115 - 203

To accompany Records 1960, No 39

PLATE 2



SEISMIC REFLECTION SURVEY NEAR LA GRANGE,
KIMBERLEY DIVISION, W. AUSTRALIA

LOCATION OF SEISMIC TRAVERSES

SCALE IN MILES

1 0 1 2 3

The position of seismic traverses obtained from field survey data.

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G115-204

To accompany Records 1960, No 49

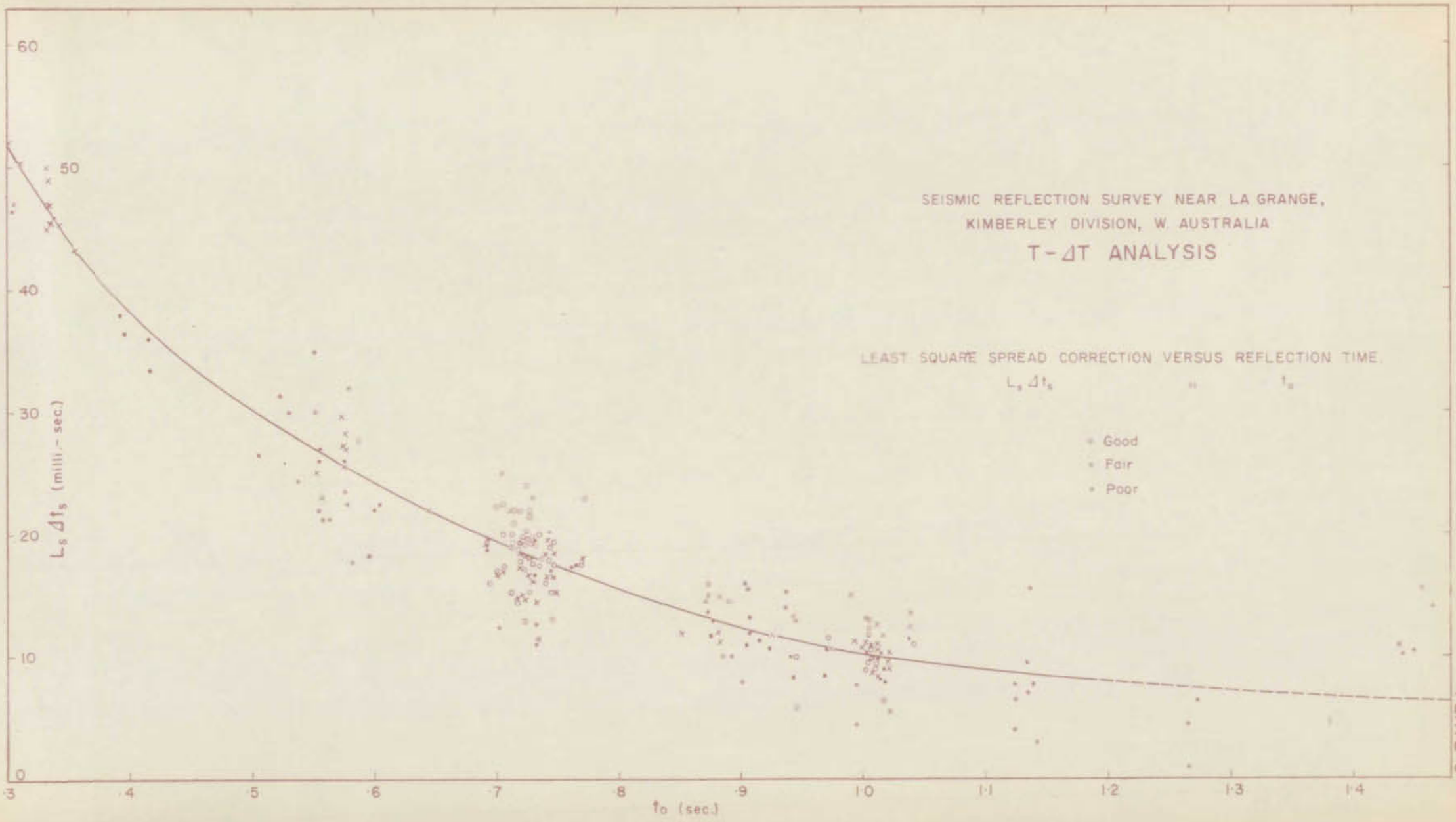
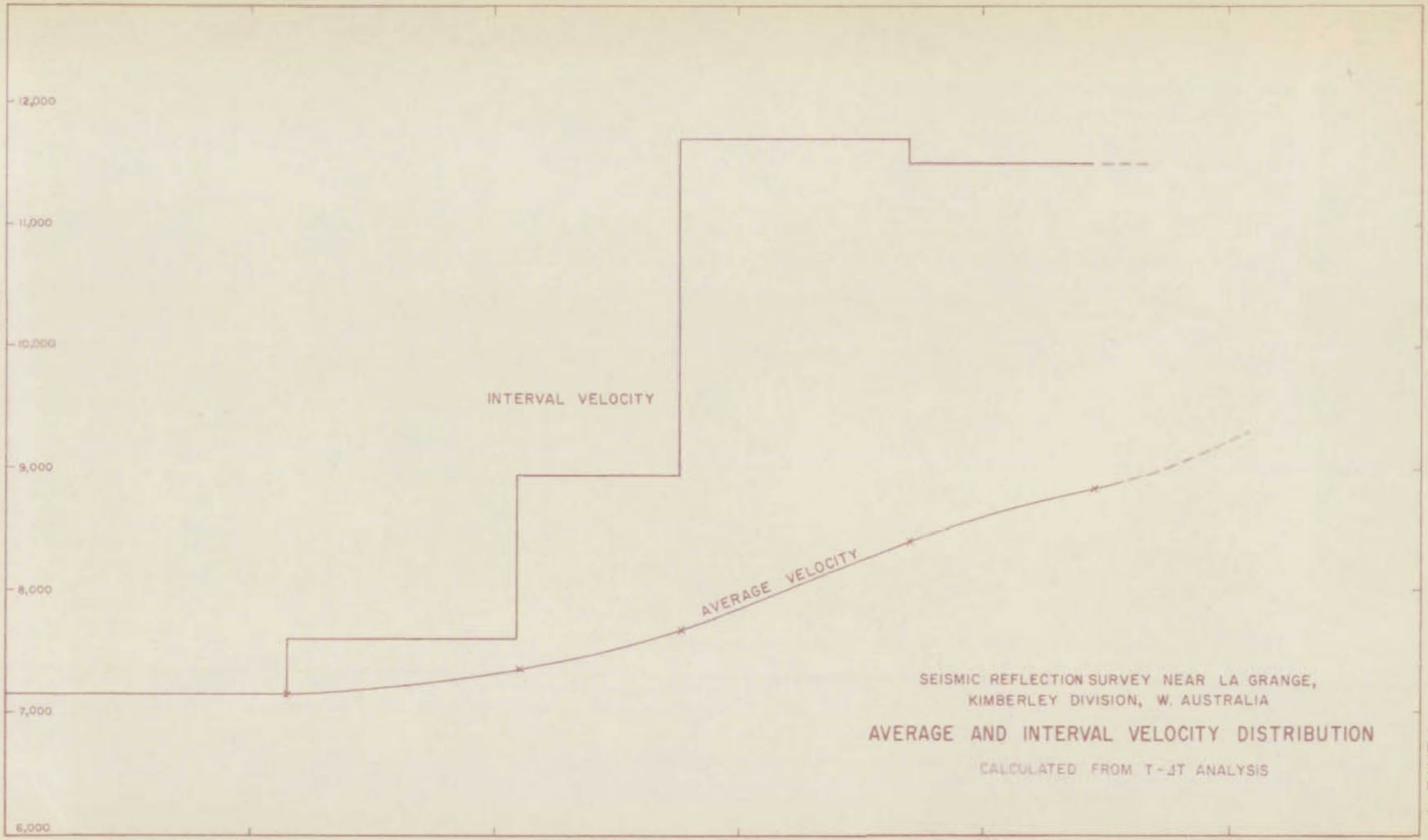


PLATE 3

G 115-208



SEISMIC REFLECTION SURVEY NEAR LA GRANGE,
KIMBERLEY DIVISION, W. AUSTRALIA

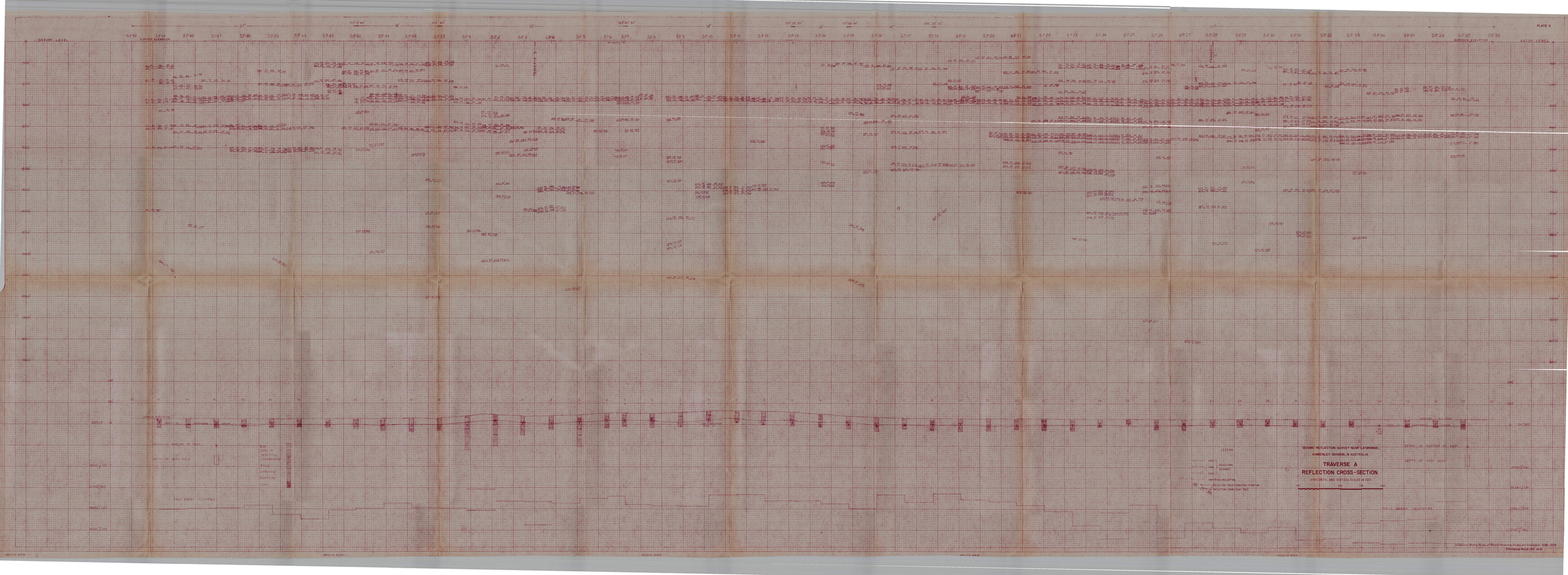
AVERAGE AND INTERVAL VELOCITY DISTRIBUTION

CALCULATED FROM T-ΔT ANALYSIS

PLATE 4

G 115-207

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics
To accompany Record 1962, No. 49



SEISMIC REFLECTION SURVEY NEAR LA GRANGE,
KIMBERLEY DIVISION, W. AUSTRALIA

TRAVERSE A
REFLECTION CROSS-SECTION

HORIZONTAL AND VERTICAL SCALES IN FEET

Bureau of Mineral Resources, Geology & Geophysics, Canberra, 535-205

PLATE 6

SP55 SP54 SP51 SP52 SP53

140'

DATUM LEVEL

SURFACE ELEVATION

TRAVERSE B

1000'
2000'
3000'
4000'
5000'
6000'
7000'
8000'
9000'
10000'
11000'

SP65 SP64 SP63 SP62 SP61 SP28 SP56 SP57 SP58 SP59 SP60

113'

DATUM LEVEL

SURFACE ELEVATION

TRAVERSE C

1000'
2000'
3000'
4000'
5000'
6000'
7000'
8000'
9000'
10000'
11000'

LEGEND

- GOOD
- FAIR } REFLECTION ACCURACY
- POOR
- UNCERTAIN REFLECTIONS
- REFLECTION TIMES CORRECTED TO DATUM
- REFLECTION GRADE (BABY, 1947)

SEISMIC REFLECTION SURVEY NEAR LA GRANGE,
KIMBERLEY DIVISION, W. AUSTRALIA

TRAVERSES B AND C
REFLECTION CROSS-SECTION

HORIZONTAL AND VERTICAL SCALES IN FEET

1000 0 1000 2000 3000

100'
200'

DATUM

SURFACE ELEVATION

DEPTH OF WEATHERED LAYER

DEPTH OF BOTTOM OF SHOT

DEPTH OF SHOT HOLE

CLAY
SAND OR SANDSTONE
CONGLOMERATE
SHALE
LIMESTONE
QUARTZITE
COAL

12000'/SEC
10000'/SEC
9000'/SEC

FIRST BREAK VELOCITIES

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G115-206
To accompany Records 1950, No 48.