COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF NATIONAL DEVELOPMENT
BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS

RECORD 1961, No. 57

BROOME SEISMIC REFLECTION SURVEY, W.A. 1954-55

by

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ABSTRACT

The Bureau of Mineral Resources conducted a seismic reflection survey of a small area near Broome, W.A., during 1954 and 1955. It was part of a general investigation of the Canning Basin and was aimed at determining the distribution of sediments south of the Fenton Fault.

The seismic work indicated a sedimentary thickness of at least 6000 feet, and probably as much as 10,000 feet could be expected. It also showed that the subsurface formations are probably folded and faulted.

1. INTRODUCTION

During 1954 the seismic party of the Bureau of Mineral Resources conducted a short seismic investigation near Broome, Western Australia, while waiting for the flooded Fitzroy River to recede so that the party could proceed to the Christmas Creek area (Vale and Williams, 1955). Although of very limited extent, this survey indicated a considerable thickness of sediments and showed that the sediments were probably folded. It was planned to conduct reconnaissance surveys throughout the Canning Basin during 1955, and as a result of the 1954 investigation, Broome was selected as one area for such a survey. The survey there was to serve the dual purpose of confirming the thickness of sediments present there and investigating the suspected folding of these sediments.

Broome is a small seaport on the north-west coast of Australia at latitude 17° 58'S and longitude 122° 14'E. The party's camp was situated on the Port Hedland road about 10 miles from Broome (Plate 1). Traverses were laid out connecting the work done in the previous survey and are shown on Plate 1.

During the 1955 survey, continuous reflection profiles were observed along four traverse lines (F, G, H, and J, Plate 1) roughly in the form of a rectangle 9 miles by 5 miles. Details of personnel, equipment, and field operations are set out in the Appendix at the end of this report.

The results of this seismic work were made known to Western Australian Petroleum Ltd. (Wapet) which holds the area under Permit to Explore. Wapet has since done extensive seismic surveys in the Broome-Derby district.

2. GEOLOGY

The Broome area lies within the Canning Basin, which covers a large portion of north-western Australia. The north-eastern portion of this Basin is called the Fitzroy Trough, and contains large thicknesses of Palaeozoic sediments. The geology of this portion is discussed fully by Guppy and others (1958). A summary of the geology of the Canning Basin relevant to the Broome area is given by Smith (1960). Briefly it can be said that Mesozoic rocks crop out nearby and probably extend to the survey area, while bores drilled some miles away by West Australian Petroleum Pty. Ltd. have encountered Palaeozoic rocks underlying the Mesozoic rocks. There has been no surface evidence of folding or faulting reported from the area of the survey.

3. RESULTS

The 1954 seismic survey was done when the party was delayed near Broome during its journey to Christmas Creek. It was necessarily of limited extent owing to its impromptu nature and the short time available. Reflection shooting was done on five crosses, with one mile arms, spaced at approximately four-mile intervals in an area east of Broome (Plate 1).

On two of these crosses the record quality was good, and numerous reflections were recorded. The results indicated a conformable sedimentary cross-section to 7000 feet and a possible total sedimentary thickness of 12,500 feet. On the other three crosses, the records were of much poorer quality but two of them did give dip information for the section above 6000 feet. The dip information obtained from the various crosses suggested that the survey was made on the south-western flank of an anticline striking north-west to south-east. Plates 4 to 8, showing the 1955 survey results, duplicate and extend the 1954 survey results, which are therefore not shown in this Record.

Surface Conditions

The area of the survey can be broadly divided into two types of topographic features. Along the coast of Roebuck Bay, low-lying mud flats, generally less than 30 feet above sea level, extend inland for some miles. Parts of them are often inundated by the sea at high tide, particularly during the high spring and autumn tides. The remainder of the area ranges between 50 and 150 feet above sea level and generally consists of red sandy country which is heavily timbered with both large trees and dense scrub.

Shot-points 18 to 2 on Traverse F and 2 to 44 on Traverse G were situated on the mud flats. The remainder of these traverses and Traverses H and J crossed the sandy timbered country. Traverse F from Shot-point 18 to 36 was along a telegraph line, and Traverse J was along the Broome-Derby Road. Hence no clearing was required along these lines. A bulldozer, lent to the party by the Department of Civil Aviation, was used to clear a line through the scrub for that section of Traverse G from Shot-Points 44 to 60 and for all of Traverse H.

The two types of surface conditions had a marked effect on the quality of the reflection records. The record quality was generally good along the mud flats, and was obtained by fairly shallow shooting. The depth of the weathering layer was about 15 to 20 feet and coincided with a well-defined water table. Shots were generally placed between 30 and 40 feet below the surface. However, there was a marked change in conditions and record character when shooting on the higher sandy country. The weathering depth increased to an average of 50 feet and shots were placed at about 100 feet, although no optimum shooting depth was really evident. In general the quality of these records was very poor, and very few reflections were recorded in this higher sandy country.

Vertical Velocity

An analysis was made of the time increments (Δt) of the reflections recorded, in order to obtain an approximate velocity distribution for the area. The least square values of the spread corrections ($Ls\Delta t_x$) for the selected reflections are shown plotted against their recorded reflection times (t_o) on Plate 2, and a best-fitting line has been drawn through them. Plate 3 shows the average velocities and interval velocities calculated from the "t, Δt" analysis. In the zone from 0.5 sec to 0.7 sec there are many good reflections, and consequently the velocities calculated at these times, corresponding to depths from 2000 feet to 2700 feet, can be regarded as reliable. Below this depth the points are much fewer and more scattered, and the velocities calculated are only approximate.

The average vertical velocity increases from 7400 ft/sec at the surface to 8800 ft/sec at 5700 feet. These values are about the same as those measured at La Grange, 60 miles south-west of Broome (Smith, 1960).

Reflection Cross-Sections

As already reported above, the quality of the records varied greatly within the area, and this variation can apparently be related to the type of surface. Over the northern part of the area, the lack of reflections, and the poor quality of the few reflections recorded, are taken to be due to poor shooting conditions rather than to a change in the geology.

The record quality was quite good along the greater part of Traverse F (Plate 4). Reflections were recorded fairly consistently down to 6000 or 7000 feet, indicating that sedimentary rocks persist to at least this depth. Further scattered reflections were recorded below this depth, and it appears possible that the sedimentary rocks may extend to at least 10,000 feet. Although the reflections recorded on other traverses (G, H, and J; Plates 5, 6, and 7) were fewer and of much poorer quality they generally support the above estimates of sedimentary thickness.

The most consistent and reliable reflections recorded are in a band from a depth of 2000 to 2700 feet, along Traverse F. The "t, Δ t" analysis demonstrates this quite well. The reflection at an average time of 0.68 sec, or 2600 feet, is by far the strongest and most consistent one recorded, and can be correlated from Shot-point 25 to Shot-point 2 along Traverse F. A similar very strong reflection at approximately the same depth was recorded at La Grange, 60 miles south-west of Broome, and one is tempted to correlate the two. However, at La Grange a marked increase in velocity occurs below this reflection, as shown by a "t, Δt" analysis and refraction shooting (Smith, 1960), but such an increase is not evident from the "t, Δ t" analysis for the Broome area.

The structure of the shallower sediments has been made evident by the construction of an horizon which in part is a straight correlation of the reflection at 2600 feet on Traverse F, but elsewhere is a "phantom" horizon, drawn by averaging the dips of the reflections above 4000 feet in those seismic cross-sections where correlation is not possible. A line has been drawn on the cross-sections to represent this horizon, and it is broken in sections where, owing to lack of reflections, it has only been extrapolated. Along Traverse J, from Shot-points 75 to 91, it was not possible to construct the horizon. Therefore the horizon has not been closed around the loop made by the four traverses.

Commencing on Traverse F, it can be seen that the horizon follows the main reflection from Shot-point 25 to Shot-point 2. At the western end it has been constructed by extrapolation across the gaps, supported by character correlation. Along Traverse G, the correlation can be continued to Shot-point 38, but ends abruptly there. A good reflection recorded on Shot-point 42 has similar character to the one lost at Shot-point 38 and has been interpreted to be the same horizon. This can be followed continuously from Shot-points 39 to 44. If this interpretation is correct, then a fault exists between Shot-points 38 and 39, with a down-throw of 650 feet on the northern side. From Shot-points 44 to 60 the horizon has been produced partly by averaging reflection dips and partly by following a particular reflection. On Traverses H and J the horizon is a phantom drawn by averaging reflection dips above 4000 feet.

The horizon has been contoured and is shown on Plate 8. With the exception of the probable fault between Shot-points 38 and 39, and neglecting minor irregularities, it is evident that the subsurface formations in this area are plunging to the south. The fault interrupts this southerly plunge. On Traverse G, the amount of south dip is decreasing towards the north. This may mean that the axis of an anticlinal structure is being approached. The saddle along Traverse J could also be related to the crestal area of an anticline.

The structure outlined above is taken from the shallower horizons only, but there is no evidence of a major angular unconformity in any of the seismic cross-sections. Therefore the structure of the whole 10,000 feet of rock is approximately that of the phantom horizon at about 2000 feet.

4. CONCLUSIONS

The sedimentary section in the area of the survey is certainly 6000 feet thick but more probably extends to at least 10,000 feet.

The subsurface formations show structural relief which cannot be suspected from visible features at the surface. Although across the area surveyed the formations are dipping to the south, there is a suggestion that this southerly dip may flatten out to the north of Traverse J. The southerly dip is probably interrupted by a fault between Shot-points 38 and 39, with down-throw of 650 feet to the north.

The seismic cross-sections give no evidence of any angular unconformity in the area.

5. REFERENCES

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

SMITH, E.R., 1960 La Grange seismic reflection survey, W.A. 1955. Bur. Min. Resour. Aust. Rec. 1960/49.

VALE, K.R. and WILLIAMS, L.W., 1955 Preliminary seismic reflection investigation Broome area, Kimberley Division, W.A. Bur. Min. Resour. Aust. Rec. 1955/112.

APPENDIX - Details of 1955 survey.

(a) Staff and Equipment

Party Leader	: E.R. Smith
Other Geophysicists	: 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 20-c/s geophones.
Drill Equipment	: 2 Failing "750" drilling rigs.
Vehicles	: International utility, 4 Land Rovers, 2 Morris-Commerical 4 x 4 one-ton trucks, 8 Commer 4 x 4 three-ton trucks.

(b) Field Data

Date commenced	: 2nd August 1955
Date completed	: 4th September 1955
Shot-point interval	: 1320 feet
No. of Geophones	: 4 per trace
Geophone spacing	: 5 feet
No. of holes shot	: 111
Total footage drilled	: 12,377 feet
No. of shooting days	: 16
Average holes shot per day	: 7

PLATE I

GANTHEAUME BAY

ROEBUCK BAY

BROOME

BROOME BEAGLE BAY ROAD

BROOME DERBY ROAD

GREAT NORTHERN HIGHWAY

TELEGRAPH LINE

Seismic Camp

TRAVERSE H

TRAVERSE J

TRAVERSE G

TRAVERSE F

TRAVERSE C

CROSS A

CROSS B

CROSS D

CROSS E

CROSS

A2 A4 A5

B4 B5

C4 C5

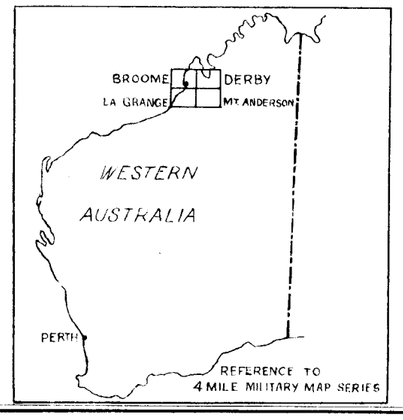
D1 D3

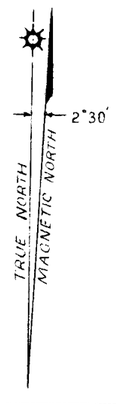
E1 E2

2A 36

17°50′ 17°55′ 18°00′

122°10′ 122°15′ 122°20′ 122°25′





SCALE IN MILES

1 0 1 2 3

CROSS A,B etc.- 1954 SEISMIC SURVEY

SEISMIC REFLECTION SURVEY, BROOME AREA, KIMBERLEY DIVISION, W. A.

POSITION OF SEISMIC TRAVERSES

G 178-11

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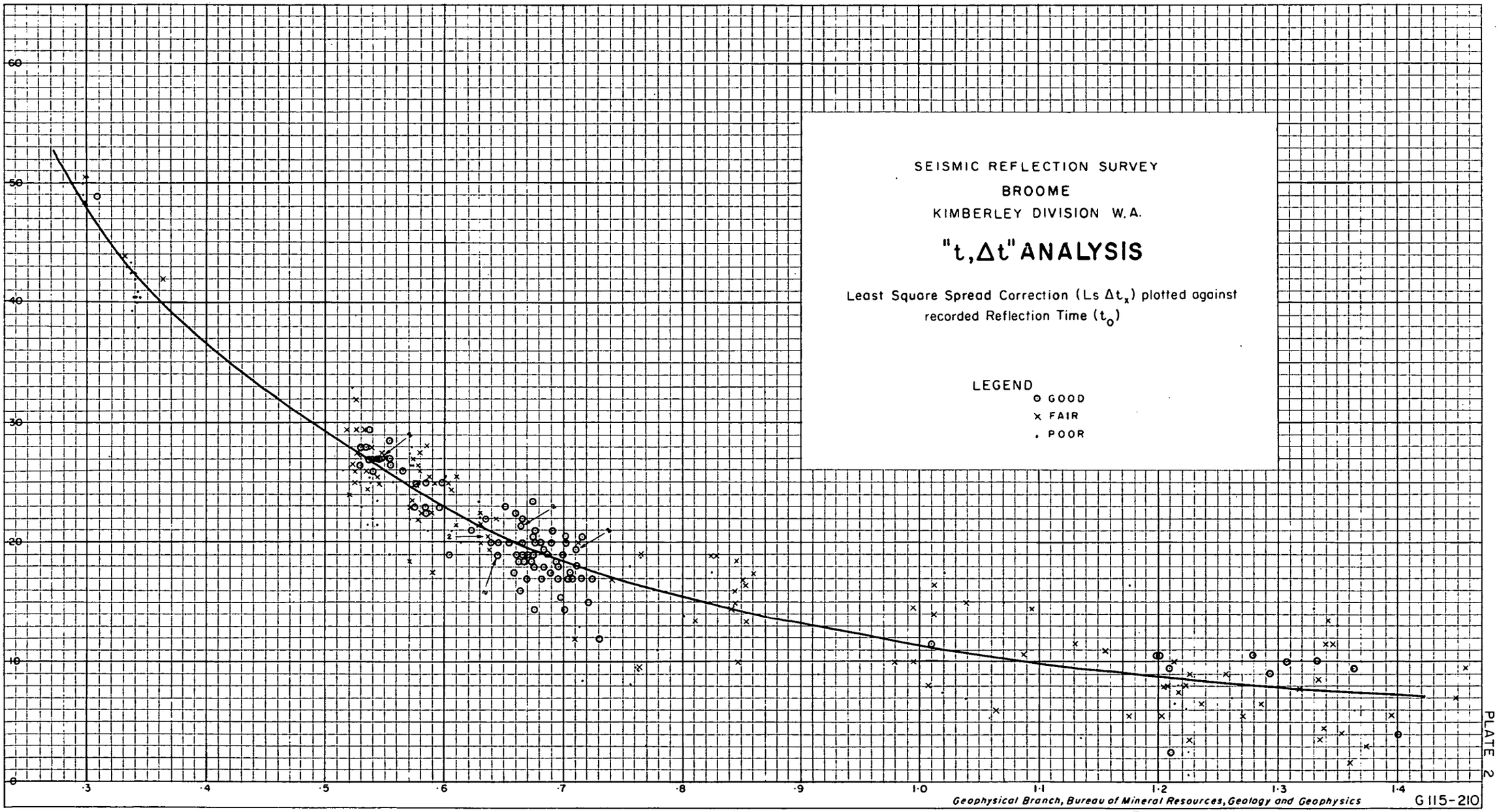

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PLATE 2

SEISMIC REFLECTION SURVEY

BROOME

KIMBERLEY DIVISION W.A.

AVERAGE AND INTERVAL VELOCITY DISTRIBUTION

CALCULATED FROM "t, Δt" ANALYSIS

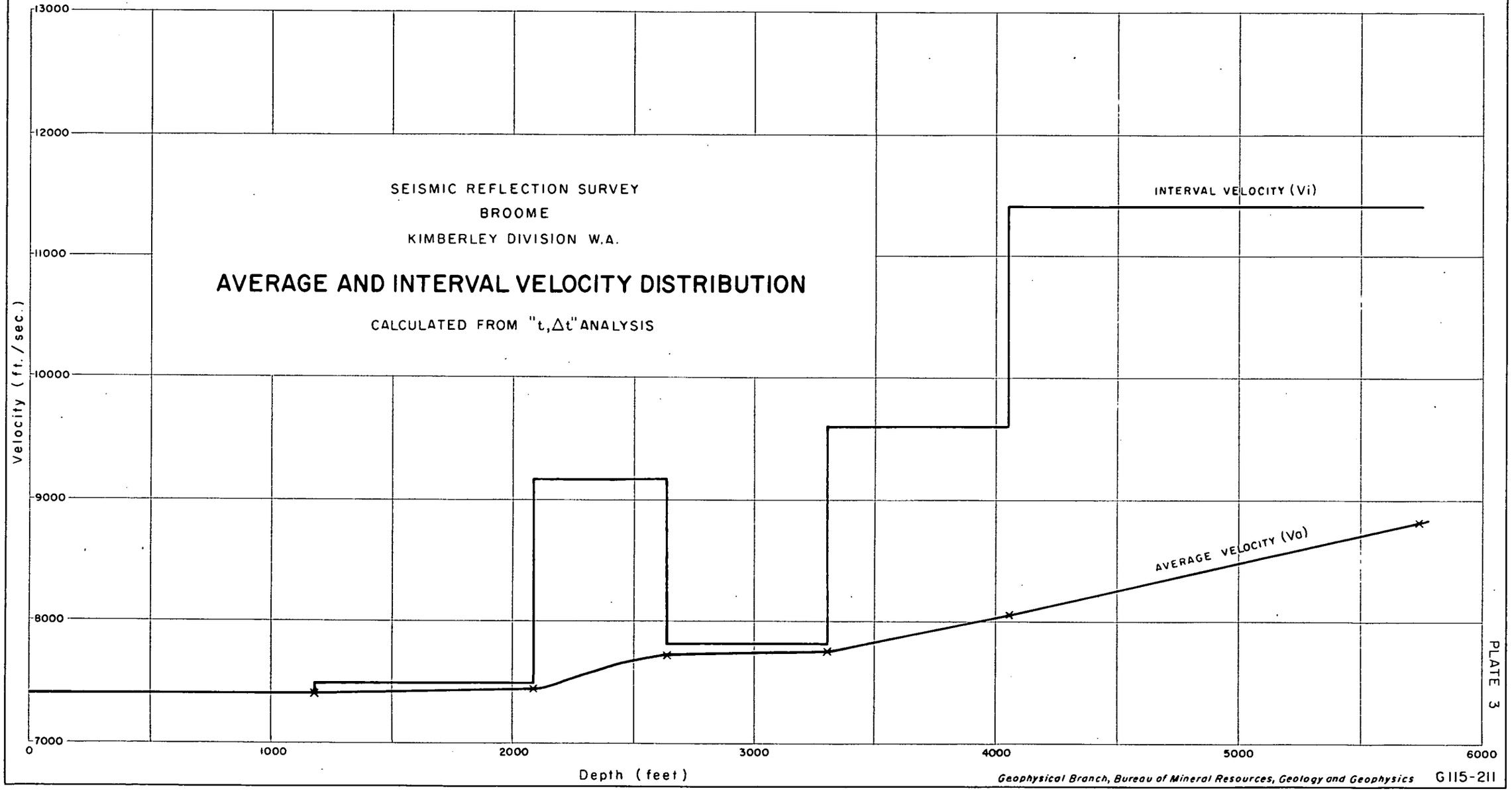

PLATE 3

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(S.L.) DATUM

DATUM (S.L.)

LEGEND

3000 — REFLECTION

FAIR

POOR

QUESTIONABLE

REFLECTION TIMES CORRECTED TO DATUM

REFLECTION GRADE (GSWA 1967)

BROOME AREA, KIMBERLEY DIVISION, W.A.
SEISMIC REFLECTION SURVEY

REFLECTION CROSS-SECTION
TRAVERSE F

HORIZONTAL AND VERTICAL SCALES IN FEET

1000 0 1000 2000 3000

DRILL LOGS

DEPTH OF BEST SHOT X

FIRST BREAK VELOCITIES

FIRST BREAK VELOCITIES

FIRST BREAK VELOCITIES

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PLATE 6

180.3°

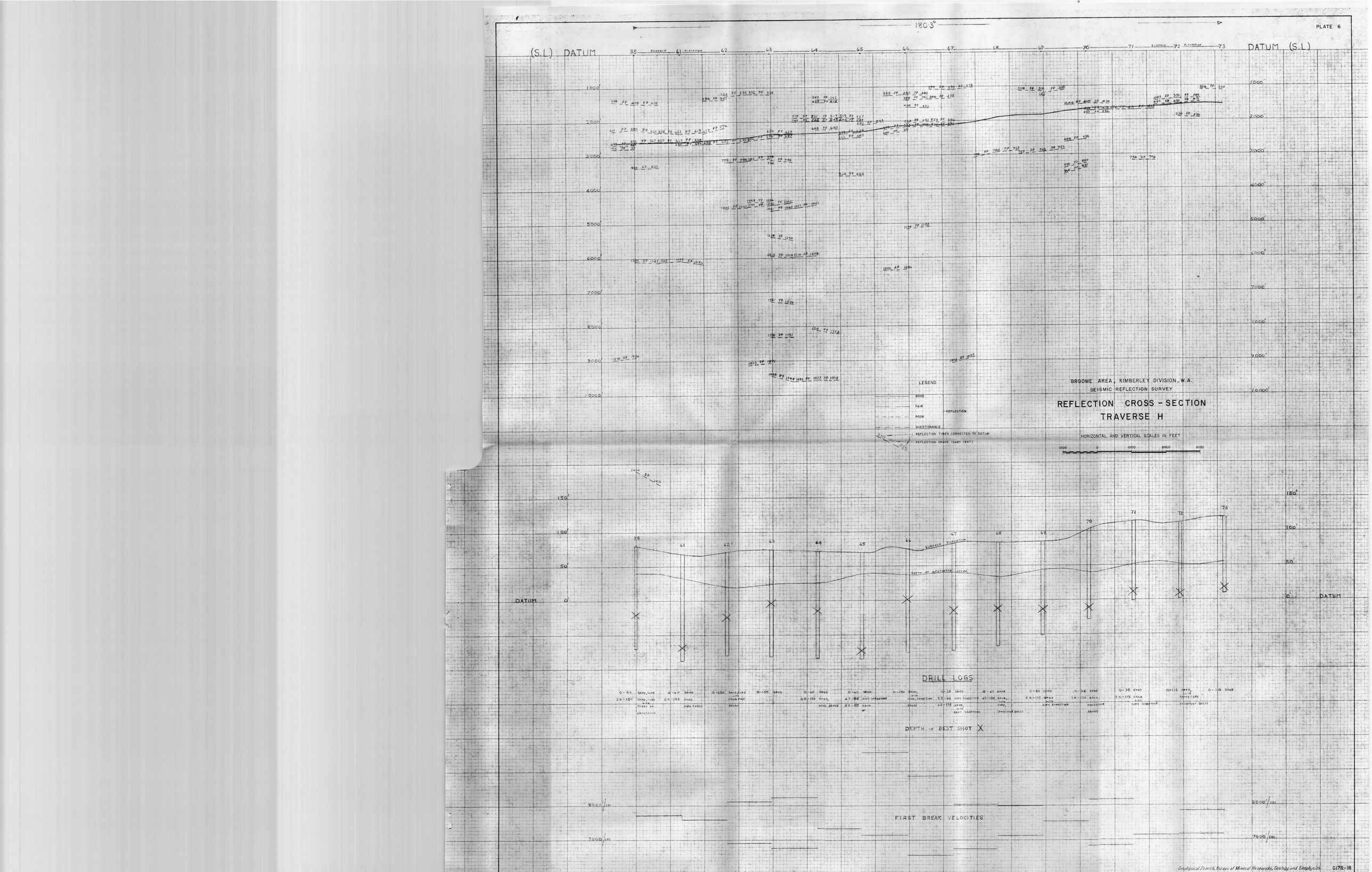

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PLATE 7
(S.L.) DATUM
DATUM (S.L.)
LEGEND
GOOD
FAIR
POOR
QUESTIONABLE
REFLECTION
REFLECTION TIMES CORRECTED TO DATUM
REFLECTION GRADE (GABY 1947)
BROOME AREA, KIMBERLEY DIVISION, W.A.
SEISMIC REFLECTION SURVEY
REFLECTION CROSS-SECTION
TRAVERSE J
HORIZONTAL AND VERTICAL SCALES IN FEET
1000 0 1000 2000 3000
DRILL LOGS
DEPTH IN FEET SHOT X
FIRST BREAK VELOCITIES
FIRST BREAK VELOCITIES
FIRST BREAK VELOCITIES
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PLATE 8

BROOME BEAGLE BAY ROAD

BROOME DERBY ROAD

GREAT NORTHERN HIGHWAY

TELEGRAPH LINE

TRAVERSE J

TRAVERSE H

TRAVERSE G

TRAVERSE F

Seismic Camp

BROOME

GANTHEAUME BAY

ROEBUK BAY

17°50'

17°55'

18°00'

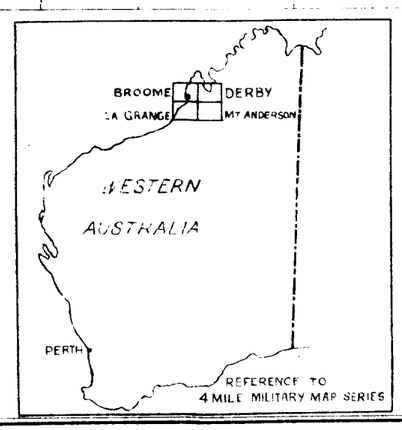
121°12'

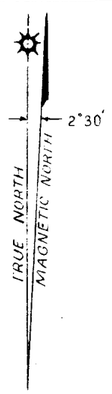
122°15'

122°20'

122°25'

122°30'





SCALE IN MILES

1 0 1 2 3

SEISMIC REFLECTION SURVEY, BROOME AREA, KIMBERLEY DIVISION, W. A.

SUBSURFACE CONTOUR MAP

DATUM: SEA LEVEL

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