1973/63
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DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD 1973/63

CRUSTAL STRUCTURE IN SOUTHWESTERN AUSTRALIA FROM SEISMIC & GRAVITY DATA

by

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Record No. 1973/63

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SUMMARY

An integrated interpretation of the seismic refraction, seismic reflection, and gravity data obtained by the Australian Bureau of Mineral Resources, Geology & Geophysics to the end of 1971 has been made to determine the nature and structure of the crust and upper mantle in the southern part of the West Australian Shield.

The crust is of normal continental type in the east but changes towards the Perth Basin in the west: near Kalgoorlie it consists of two layers with velocities of 6.12 and 6.66 km/s and is 34 km thick, whereas near Perth, close to the continental margin, it is 44 km thick and includes an extra basal layer of velocity 7.42 km/s, which thins out towards the east and southeast. The upper two crustal layers near Perth, on the other hand, thicken to the east and southeast. In the Perth Basin, about 7.5 km of sediments overlie a block of the crust which has been thrown down to the west along the Darling Fault. Southeast of Coolgardie, the high-velocity basal layer is shown to be thin and the southeastern part of the crustal block has been upthrust to the northwest along the Fraser Fault. The measured velocity of the upper mantle underneath the abnormal crust is 8.25 km/s.

Two possible density models for the seismically determined structure of the crust and upper mantle have been obtained which are consistent with isostatically balanced shield crust and the gravity anomalies in southwestern Australia. One of the models is also consistent with the hypothesis that the high-velocity basal layer in the crust is garnet granulite overlying eclogitic mantle.

INTRODUCTION

During the last two decades, a substantial amount of seismic and gravity data has been obtained by the Australian Bureau of Mineral Resources, Geology & Geophysics (BMR) in southwestern Australia. Reconnaissance gravity surveys were made in 1951-52 in the Perth Basin (Thyer & Everingham, 1956) and in 1969 over the Precambrian shield (Fraser, in prep). Seismic travel times from explosions over land as well as offshore have been recorded since 1959 at the Mundaring Geophysical Observatory and other temporary stations in the field (Gregson & Woad, 1968; Everingham, 1969, 1970). As a major contribution to the Upper Mantle Project in 1969, deep crustal refractions and reflections were recorded along the Geotraverse, a line across the shield extending from Perth east to Coolgardie and thence southeast towards Point Culver on the Great Australian Bight (Gregson & Paull, 1971; Branson, in prep). In this paper are presented the results of a combined analysis of these data to determine the nature and structure of the crust and upper mantle in the southern part of the West Australian Shield.

GEOLOGICAL SETTING

The geology of the shield area has been described by Prider (1965), Sprigg (1967), Wilson (1969), and others. The main geological and tectonic features of the area are shown in Figure 1.

The largest and oldest part of the shield is the Yilgarn Block, which is made up mainly of Archaean gneiss and lenticular masses of 'greenstone' and metasediments and is intruded by massive granites. On the west, the Yilgarn Block is bounded by the Perth Basin, the western boundary of which is defined by a partly submerged ridge of Precambrian rocks. This ridge forms an outlying part of the shield, and is exposed in the south between Cape Leeuwin and Cape Naturaliste. On the south and the southeast, the Yilgarn Block is girded by a belt of Proterozoic granulite of the

Albany-Esperance and Fraser Range Blocks, with faulting (Bremer and Fraser Faults) along their junctions. East of the Fraser Range, the marine sediments of the Eucla Basin define the eastern boundary.

PREVIOUS STUDIES

Gravity studies of the Perth Basin by Thyer & Everingham (1956) indicate that the basin is a narrow elongated graben bounded for the most part by normal faults of great magnitude. Sediment thicknesses in excess of 10 km have been estimated from the gravity minimum of less than -130 mgal in the basin. The Darling Fault on the east appears from the gravity evidence to be a normal fault dipping steeply (70°-80°) to the west with a maximum throw of 9 km or more. The results of seismic surveys near Perth made in 1955-56 by BMR (Thyer, 1963) confirmed the presence of at least 6 km of sediments bounded on the east by the Darling Fault. Marine geophysical surveys offshore (Hawkins, Hennion, Nafe & Thyer, 1965) indicate that the Perth Basin broadens westward north of Cape Naturaliste, that it has about 5.7 km of sediments in the area west of Perth and an eastward tilted basement forms its western margin.

Studies of seismic data by Everingham (1965) from explosions offshore and on land showed that in the Perth Basin about 6 km of sediments of 2.94 km/s velocity overlie a downthrown block of crust and the shield crust east of the Darling Fault consists of two layers with velocities 6.18 and 7.24 km/s and overlies a mantle with velocity 8.48 km/s. The thicknesses of the crustal layers were computed to be 14 and 28 km respectively.

Seismic refractions from the 1956 atomic tests at Maralinga, S.A. were studied by Bolt, Doyle & Sutton (1958) and indicated a single-layer crust 32 km thick and velocities of 6.03 km/s for the crust and 8.21 km/s for the mantle in the eastern part of Western Australia. Doyle & Everingham (1964) recomputed the crustal thickness in this area to be 35 km using a more reliable crustal velocity of 6.30 km/s obtained from the profile southeast of Maralinga.

On the basis of the geomorphology, seismicity, and gravity anomalies of the southwestern part of Western Australia, Everingham (1965, 1966) has suggested that a change in the crust, and possibly in the upper mantle, probably occurs about 110 km east of Perth along a NNW-trending seismic zone (Yandanooka-Cape Riche Lineament) which closely follows the -20 mGal contour and across which the Bouguer anomaly values change from high on the west to low on the east.

Results of marine seismic refraction studies by Hawkins, Hennion, Nafe & Doyle (1965) on the continental margin, south of Point D'Entrecasteaux indicated shallowing of the base of the oceanic layer towards the continent to a depth of about 10.5 km roughly 120 km south of the coastline. The underlying velocity was calculated as 8.07 km/s. But this figure could include travel times from an intermediate layer in the zone of crustal transition, and hence the above results are considered inconclusive.

Seismic refraction studies by Francis & Raitt (1967) in the southeastern Indian Ocean have indicated that the crust under the Broken Ridge, though only about 20 km thick, is almost continental and includes a high-velocity (7.25 km/s) basal layer. On the basis of physiographic similarity between the Broken Ridge and Naturaliste Plateau, these authors suggest that the ridge was once a part of the West Australian Shield, and that the crust in between has been thinned either tectonically or because of the rising of the mantle at the expense of crust by some process at the Moho.

A comprehensive review of all deep crustal seismic studies done in the Australian region has been made by Dooley (1970) who came to the following general conclusions about the nature of the crust and upper mantle. The depth to the mantle over the mainland is generally about 35-40 km where seismic data are available. The P_n velocity ranges from 7.67 km/s under Bass Strait to 8.42 km/s under the Perth Basin, and it correlates in a general way with heat flow measurements, which are lower in the West Australian Shield than in eastern Australia. An intermediate layer has been deduced in many places. From an analysis of the results of large-scale crustal refraction experiments in Australia, Cleary (1971) arrived at similar conclusions that both P_1 and P_n velocities are higher in the Precambrian shield region than in eastern Australia and appear to increase systematically from east to west across the continent, that there is good evidence in all parts of Australia for an intermediate layer with an average depth of 20 km to the Conrad discontinuity, and that the crustal thickness has an average value of about 40 km.

ANALYSIS OF DATA

The analysis of BMR seismic and gravity data was carried out in three steps:

1. The refraction data were used to obtain velocities and a structure model of the crust.
2. The reflection results were used to provide check points on the refraction interpretation.
3. The gravity data were studied to ascertain if the seismically derived structure was consistent with the gravity field, and to obtain density estimates for the crust and upper mantle.

Refraction data

The locations of shots and receiving stations for the refraction data used in this study are shown in Figure 2. They were chosen to lie roughly along two traverses, one between Perth and the Jubilee Mine near Kalgoorlie and the other between Perth and Albany. The travel times which correspond to the actual distances from individual shots have been plotted in Figures 3 and 4 with shot origins grouped around offshore-Perth (OFF-P), shield boundary near Perth (SB), Hines Hill (HHL), Boorabbin (BOO), Jubilee Mine (JUB), and offshore-Albany (OFF-A). The time-distance curves therefore represent average conditions along the two traverses.

From first as well as later arrivals, the equations for the travel-time segments were determined using the method of least-squares and incorporating the principle of reversed-time equivalence. The crustal sections shown below the travel-time plots were then obtained from the apparent velocities and time-intercepts for each layer employing formulas for uniform plane dipping layers. No corrections in the computed velocities and depths to account for the curvature of the earth, as suggested by Mereu (1967), have been made, for they are estimated to be less than 1 percent for the traverse lengths involved. In Figures 3 and 4, heavy lines indicate the interfaces where the data are reliable, thin lines where the data are poor and dashed lines where they are inferred. The details of the analysis are given by Mathur, Branson & Moss (in prep.).

The results of analysis along the traverse between Perth and the Jubilee Mine indicate (Fig. 3) that near Kalgoorlie the crust is 34 km thick and consists of two layers with velocities 6.13 and 6.74 km/s. In the western part of the shield, the crust consists of three layers with velocities 6.13, 6.70, and 7.49 and is about 45 km thick near Perth, close to the continental margin. The velocity of the upper mantle is calculated to be 8.39 km/s under the shield. In the Perth Basin, about 7.5 km of sediments, consisting of two layers with velocities 2.52 and 4.67 km/s, overlie a downthrown block of the crust which is tilted to the east.

The crust along the traverse between Perth and Albany, shown in Figure 4, also consists of three layers with velocities 6.11, 6.60, and 7.34 km/s and is shown to be about 44 km thick near Perth and about 34 km thick near Albany. The subcrustal velocity is measured to be 8.11 km/s in this direction.

Table 1. Comparison of velocities and depths near Perth

Layer	Velocity (km/s)			Depth (km)		
	E-W	NW-SE	Diff.	E-W	NW-SE	Diff.
Crust 1	6.13	6.11	.01	0	0	0
Crust 2	6.72	6.60	.12	6.94	7.95	1.01
Crust 3	7.49	7.34	.15	13.26	16.24	2.98
Mantle	8.39	8.11	.28	45.00	43.60	1.40

The results from the two traverses are compared in Table 1. The depths calculated near Perth agree within 3 km and the velocities in the NW-SE direction are somewhat (up to 4 percent) lower than those in the E-W direction. These variations are within the accuracy of the refraction method, which has been estimated by Wollard (1959) to be about ±10 percent.

The calculated thickness of the crust at the coast near Albany, however, may not be realistic as the assumption of plane dipping surfaces implied in the formulas would not hold if the rise in the mantle is steeper in this area than farther inland.

Reflection data

It was in the five areas outlined in Figure 2 that deep crustal reflections were systematically recorded for the first time in Australia, after experimentation in eastern Australia (Branson, Moss & Taylor, 1972; Taylor, Moss & Branson, 1972) to develop suitable recording techniques. The reflection surveys, the details of which are discussed by Branson (in prep.), included continuous profiling, common depth point and offset recording along short traverses. The recorded sections have been digitally processed for signal enhancement, and the main reflection sections are presented in Figure 5. They are superimposed on a crustal model based on the refraction interpretation and structural information from surface geology. In the sections between Perth and Coolgardie, zones of fair-quality reflections can be identified corresponding to the refracting horizons, which have been plotted as two-way reflection travel times using refraction velocities. Between Coolgardie and Point Culver, no refraction data are available for comparison, but bands of fair- to poor-quality reflections can be picked at times which may correspond to the crustal interfaces in this area.

Gravity data

The results of gravity surveys have been reproduced here in Figures 6 and 7 as regional free-air and Bouguer anomaly maps of southwestern Australia.

The generally low amplitude (±20 mGal) of the free-air anomalies over most of the shield, except along the tectonic zones of the Darling and Fraser Faults and the area between Perth and Albany in the southwest corner, indicates that the shield crust on the whole is in isostatic equilibrium. The tectonic zones are too narrow to be compensated, whereas in the southwest the positive (+30 to 40 mGal) anomalies, which show longer wavelengths, are believed to reflect the excess mass in the basal layer of the crust rather than a departure from isostasy.

The Bouguer anomaly map shows excellent correlation with the major geologic and tectonic features in southwestern Australia. The extensive low along the western coast correlates with the Perth Basin, the low in the south with Albany granite, the zone of high positive anomalies in the southeast with the denser mass in the Fraser Range Block, the shorter-wavelength highs in the northeast with the 'greenstones' of the Kalgoorlie area, etc. These relations are discussed in detail by Daniels (1971) and Fraser (in prep.).

In order to ascertain whether the seismically derived structure of the crust is consistent with the gravity field, gravity effects were computed for the structure and compared with the mean (the longer-wavelength component) of the observed Bouguer anomalies. These effects are normally computed on the assumptions of two-dimensionality of the structure, a sea level standard column, and densities assigned to the layers according to a known relation with their velocities. The assumption of two-dimensionality, which is usually made for ease of calculations, is valid if there are no major variations in structure perpendicular to the profile studied. But the choice of densities for the layers and a standard column is not simple in view of the several different density-velocity relations that have been observed by different investigators (Fig. 8) and several different standard columns, ranging in thickness from 30 to 35 km and in density from 2.84 to 2.93 g/cm^3, that have been found suitable in different areas of the Earth's crust. Therefore, estimates of appropriate values for southwestern Australia were made differently, as follows:

As the gravity-effect computations involve density contrasts between the layers, and not the densities themselves, density-contrast models (Table 2) for three assumed standard column thicknesses were obtained such that the computed effects for each model showed a good agreement with the mean observed Bouguer anomalies. From these contrast values, densities for the lower crustal layers as well as the upper mantle were calculated, as in Table 2, on the basis of a density of 2.78 g/cm^3 for the upper crustal layer with velocity 6.12 km/s. This value is considered to be a reasonable estimate for the density of crystalline shield rocks. Rejecting Model III, which gives too high a density for the upper mantle, Model II implies an eclogitic and Model I a peridotitic subcrustal material.

The values computed for Model II along three traverses across the shield are shown in Figures 9, 10 and 11. The structural section in Figure 9 is based on both refraction and reflection data, in Figure 10 on refraction data alone, and in Figure 11 on reflection data alone. In each case, the computed curves match well with the observed mean Bouguer anomaly profile as the shorter-wavelength variations in the observed anomaly can be correlated with the surface geology, i.e., the highs with denser 'greenstones' and the lows with lighter granites.

Table 2. Density models of the crust and upper mantle

		Model I		Model II		Model III	
Standard Column	Thickness H_{st}, km	30.0		31.0		32.0	
	Density ρ_{st}, g/cm^3	2.83		2.84		2.86	
Crustal Layer	Velocity km/s	Density, g/cm^3					
		ρ	$\Delta\rho$	ρ	$\Delta\rho$	ρ	$\Delta\rho$
1	6.12	2.78		2.78		2.78	
			0.13		0.16		0.20
2	6.66	2.91		2.94		2.98	
			0.13		0.16		0.20
3	7.42	3.04		3.10		3.18	
			0.26		0.35		0.50
Mantle	8.25	3.30		3.45		3.68	

If the crust, which the free-air anomalies show to be in isostatic equilibrium, is floating in the mantle according to Archimedes' Principle, the density of the upper mantle can also be calculated from the densities and thicknesses of the crustal layers and the standard column. Upper mantle densities so computed for four areas of the shield and for crustal density Models I and II are given in Table 3. The calculated values show a systematic increase in the density of subcrustal material from 3.17 g/cm^3 under the normal crust in the east to 3.35 under the abnormal crust in the west for Model I and from 3.28 to 3.51 for Model II. The average of these values for each model agrees with the density of the upper mantle derived independently in Table 2. But the significance of the westward increase in the density is not clear.

Table 3. Upper mantle density calculations based on Archimedes' Principle

Area		Shield Boundary	Hines Hill	Boorabbin	Jubilee Mine
Elevation Δh, km		0.30	0.40	0.40	0.40
		Thickness, km			
Crustal layer 1		7.45	13.60	19.76	19.61
Crustal layer 2		7.31	8.33	9.34	14.69
Crustal layer 3		29.64	18.02	6.39	-
Total crust H_S		44.40	39.95	35.49	34.30
		Density, g/cm^3			
Model I	Crust ρ_c	2.98	2.92	2.86	2.84
	Mantle* ρ_m	3.35	3.34	3.26	3.17
Model II	Crust ρ_c	3.02	2.96	2.88	2.85
	Mantle* ρ_m	3.51	3.50	3.41	3.28

* Density computed using $\rho_m = \rho_c + \dfrac{\rho_c \cdot \Delta h + H_{ST}(\rho_c - \rho_{ST})}{H_S - H_{ST}}$ after Woollard (1969).

The seismically derived structure of the shield crust is thus in isostatic equilibrium and consistent with the observed Bouguer anomalies for either of the two density models I and II. The densities of the layers in either of the models are within the range of values observed in Figure 8 for the corresponding seismic velocities.

Summary

The results of integrated analysis of seismic and gravity data in southwestern Australia are shown in a fence diagram in Figure 12. The crust is of normal continental type in the east but becomes abnormal towards the Perth Basin in the west. It consists of two layers with velocities 6.12 and 6.66 km/s and is 34 km thick near the Jubilee Mine (Kalgoorlie), whereas, near Perth, close to the continental margin, it is 44 km thick and includes an extra basal layer of velocity 7.42 km/s, which thins out towards the east and southeast. The upper two layers near Perth, on the other hand, thicken to the east and southeast. In the Perth Basin, about 7.5 km of sediments overlie a block of crust which has been thrown down to the west along the Darling Fault. Southeast of Coolgardie, the high-velocity basal layer is shown to be thin and the southeastern part of the crustal block has been upthrust to the northwest along the Fraser Fault. The average velocity of the subcrustal material under the abnormal shield is 8.25 km/s. This structure is consistent with a crust in isostatic equilibrium and with the observed gravity anomaly field in southwestern Australia for two possible density models of the crust and upper mantle.

The refraction data used in the above analyses had been recorded on a regional scale, and the interpretation therefore represents the average structure in the crust. These data are considered inadequate for detecting small-scale features like the seismic zone (Everingham, 1965, 1966) which may not involve a major displacement of the crustal layers. The rise in the Bouguer anomalies across the -20 mGal contour, suggested by Everingham to be related to the seismic zone, seems to be a part of the regional gradient between the low anomalies in the centre and high in the southwest of the area shown (Fig. 7); this gradient reflects the southwestward thickening of the denser layer at the base of the crust.

DISCUSSION AND CONCLUSIONS

The presence of a high-velocity (7.4-7.8 km/s) basal layer in the crust has been detected in several regions of the Earth's crust. Ito & Kennedy (1970) summarized the relevant seismic data from such areas and observed that most of these areas have been associated with tectonic activity. Drake & Nafe (1968), correlating the seismic refraction data with geologic structure, suggested that the material in the velocity range 7.2-7.7 km/s may be of a transient nature and may appear and then disappear during the orogenic history of a region. While relating gravity anomalies to seismically defined crustal structure in North America, Woollard (1968) concluded that areas of abnormal crustal thickness and density are characterized by a well-defined high-velocity (6.8-7.4 km/s) basal crustal layer, an abnormal mantle velocity, positive gravity anomalies, and associated with a basin, whereas the areas where the crust is subnormal in density and thickness are characterized by subnormal mantle velocity, deficiency in gravity, and evidence of uplift. Woollard therefore believes (1970) that at the Mohorovicic Discontinuity there is an active reversible process that involves a transfer of mass between the crust and mantle in order to maintain isostatic equilibrium.

In an effort to explain the differences in crustal thickness observed over the Earth, Kennedy (1959) proposed that the vertical movement of the Moho discontinuity could result from a reversible transformation between basalt and eclogite controlled by differences in thermal gradient in the crust. Recent experiments by Ito & Kennedy (1970) further show that the basalt-eclogite transition consists of two sharp density changes; from basalt and pyroxene granulite (ρ = 3.0 g/cm^3) to garnet granulite (ρ = 3.2-3.25) and from garnet granulite to eclogite (ρ = 3.4-3.5). Therefore, they propose that the high-velocity basal crustal layer beneath areas which have undergone recent vertical movement is garnet granulite and that its upper boundary is likely to represent a chemical change from acidic and intermediate rocks to basic garnet granulite and its lower boundary a phase change from garnet granulite to eclogite. However, Green & Ringwood (1972) disagree with Ito & Kennedy's interpretation of the experimental results in terms of a two-step density increase during the basalt-eclogite transition and reaffirm their own earlier (Ringwood & Green, 1966) conclusions that the increase in density and seismic velocity is uniformly spread over the entire garnet granulite transition interval and that the basalt-eclogite transition does not explain the existence of a Moho discontinuity in stable continental crustal environments. In reply, the former authors (Kennedy & Ito, 1972) refute the objections raised by Green & Ringwood and hold to their interpretation of the data and to their view that the layer with velocity 7.5 km/s, where present, may well be garnet granulite and the velocity jump from 7.5 to 8.2 may represent the transition from garnet granulite to eclogite.

In southwestern Australia, the western part of the shield crust is abnormal in thickness and density owing to the presence of high-velocity (7.42 km/s) basal layer which thins out eastwards under the normal continental shield. The abnormal crust is associated with positive gravity anomalies and with a major tectonic feature, the Perth Basin. The basal crustal layer is well defined by seismic refractions and reflections, which imply sharp density contrasts at its boundaries. If this layer is garnet granulite derived from the eclogitic mantle underneath, the density Model II, presented in the Table 2, would better represent the structure in this area.

ACKNOWLEDGEMENTS

The author is grateful to F.J. Moss and J.C. Branson of BMR and to Dr G.P. Woollard of the University of Hawaii for discussions during the interpretation.

This paper is published with the permission of the Director, Bureau of Mineral Resources, Geology & Geophysics, Canberra, Australia.

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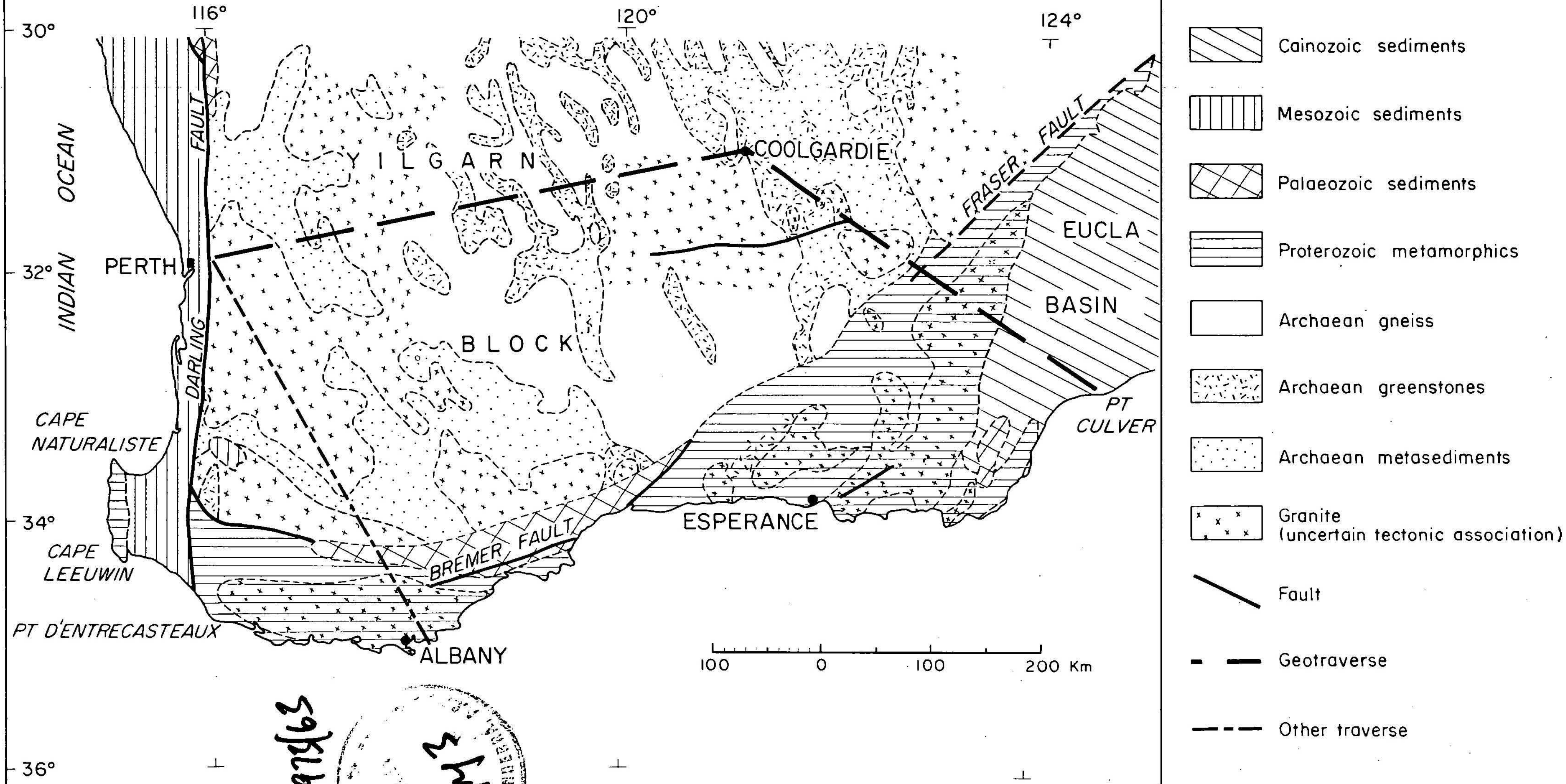


Fig. 1
GENERALIZED GEOLOGICAL MAP OF SOUTHWESTERN AUSTRALIA

Note: This map is based on Geological Society of Australia, 1971–Tectonic Map of Australia and New Guinea 1:5 000 000. Sydney

To accompany Record No. 1973/63

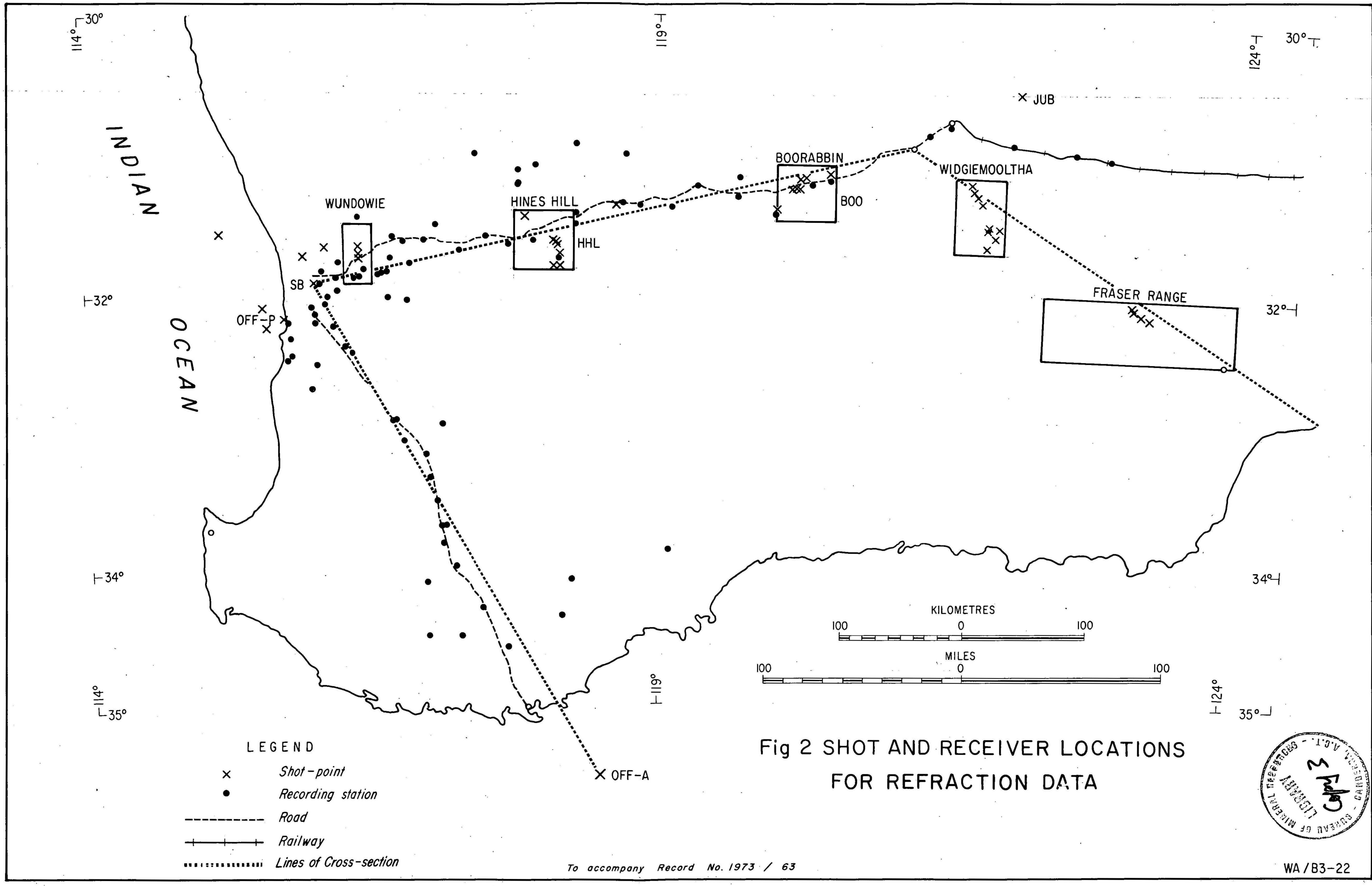
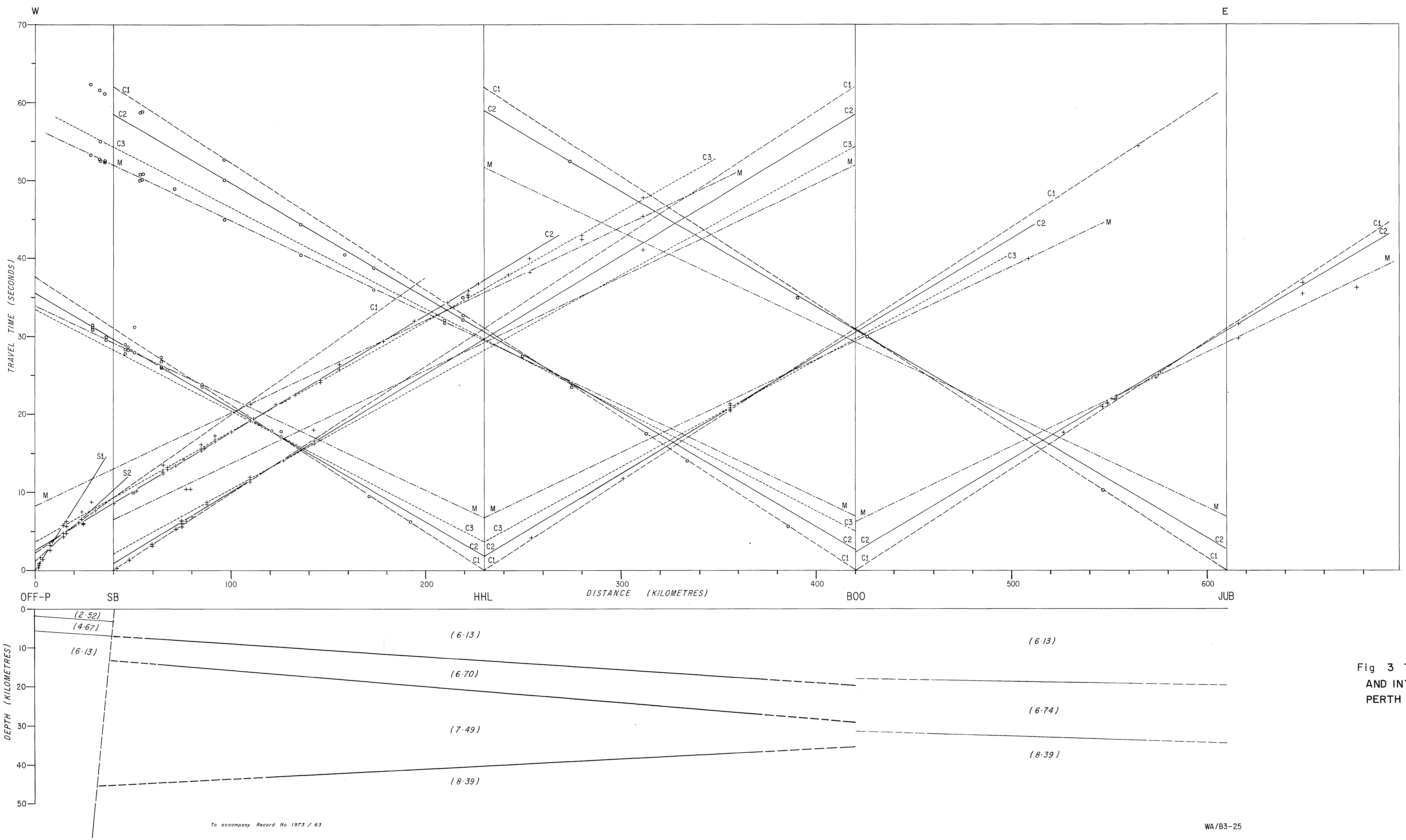


Fig 2 SHOT AND RECEIVER LOCATIONS FOR REFRACTION DATA

Record 1973/63



OFF-P (E)
S1 Δ / (2·52 ± 0·01)
S2 Δ / (4·41 ± 0·06) + (1·15 ± 0·06)
C1 Δ / (5·65 ± 0·04) + (2·23 ± 0·03)
C2 Δ / (6·63 ± 0·02) + (2·53 ± 0·05)
C3 Δ / (7·08 ± 0·03) + (3·67 ± 0·10)
M Δ / (8·37 ± 0·06) + (8·16 ± 0·17)

SB (E)
C1 Δ / (6·13 ± 0·01)
C2 Δ / (6·61 ± 0·02) + (0·92 ± 0·07)
C3 Δ / (7·29 ± 0·01) + (2·14 ± 0·05)
* M Δ / 8·37 + 6·51

BOO (W)
C1 Δ / (6·13 ± 0·01)
C2 Δ / (6·81 ± 0·09) + (2·61 ± 0·46)
C3 Δ / (7·71 ± 0·00) + (4·95 ± 0·00)
M Δ / (8·44 ± 0·04) + (6·87 ± 0·18)

BOO (E)
C1 Δ / (6·13 ± 0·01)
C2 Δ / (6·72 ± 0·00) + (2·44 ± 0·00)
M Δ / (8·29 ± 0·39) + (6·32 ± 0·86)

JUB (W)
C1 Δ / (6·13 ± 0·01)
C2 Δ / (6·76 ± 0·12) + (2·67 ± 0·60)
* M Δ / 8·50 + 6·92

* ASSUMED VELOCITY

Fig 3 TIME - DISTANCE CURVES AND INTERPRETATION BETWEEN PERTH AND THE JUBILEE MINE

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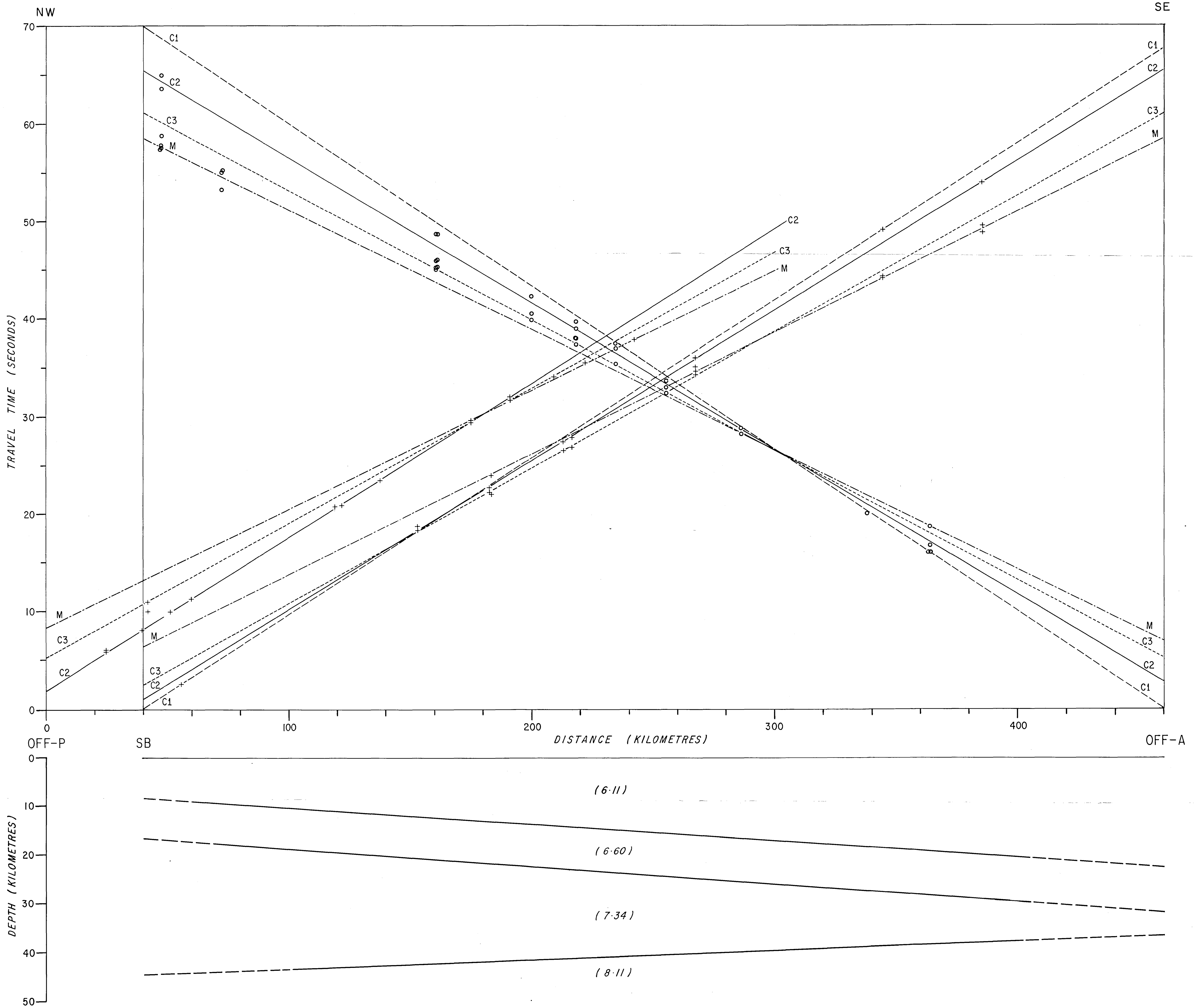

OFF-P (SE)
C2 Δ / (6·35 ± 0·02) + (1·91 ± 0·07)
C3 Δ / (7·22 ± 0·01) + (5·19 ± 0·04)
M Δ / (8·19 ± 0·09) + (8·31 ± 0·28)

SB (SE)
C1 Δ / (6·20 ± 0·01)
C2 Δ / (6·52 ± 0·02) + (0·98 ± 0·12)
C3 Δ / (7·18 ± 0·02) + (2·54 ± 0·10)
M Δ / (8·07 ± 0·06) + (6·34 ± 0·29)

OFF-A (NW)
C1 Δ / (6·02 ± 0·02)
C2 Δ / (6·69 ± 0·05) + (2·76 ± 0·32)
C3 Δ / (7·52 ± 0·01) + (5·26 ± 0·07)
M Δ / (8·16 ± 0·02) + (7·02 ± 0·13)

Fig 4 TIME - DISTANCE CURVES AND INTERPRETATION BETWEEN PERTH AND ALBANY

WA/B3-27

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Fig 5 REFLECTION RESULTS AND STRUCTURE ALONG GEOTRAVERSE

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WA/B3-28

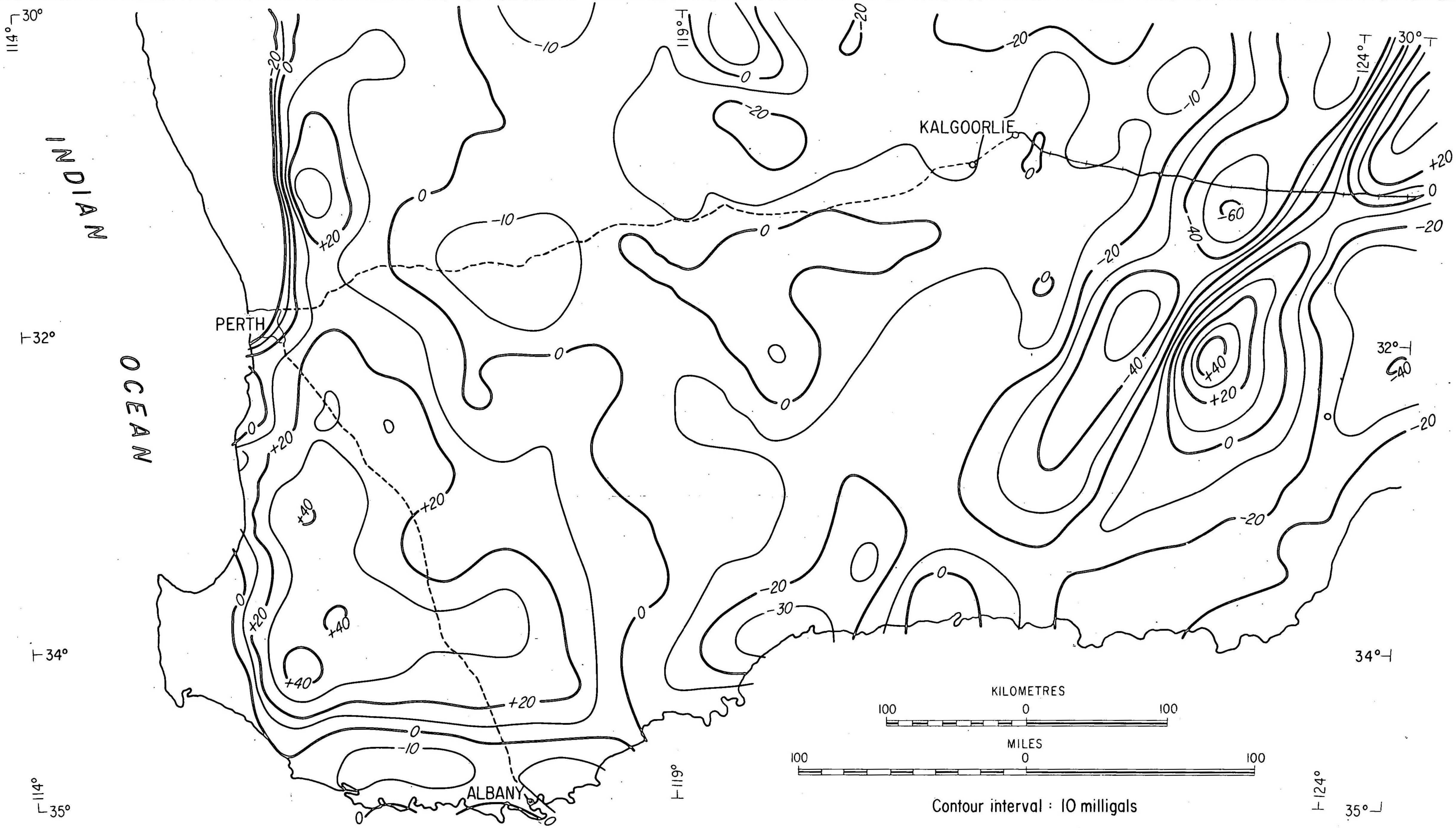


Fig 6 REGIONAL FREE-AIR ANOMALY MAP

To accompany Record No. 1973 / 63

Record 1973/63

WA/B3-20

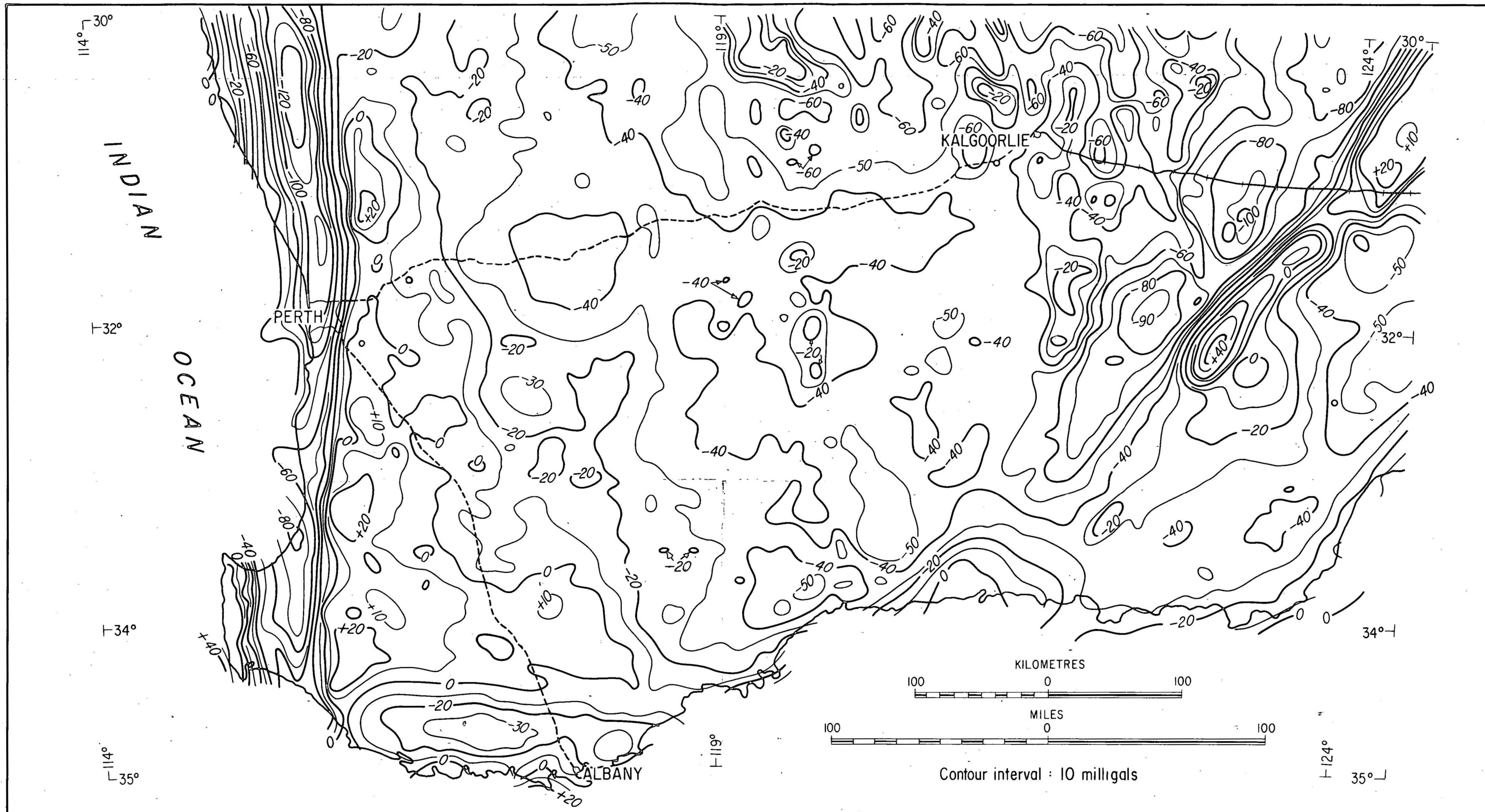


Fig 7 BOUGUER ANOMALY MAP

To accompany Record No. 1973 / 63

WA / B3-18

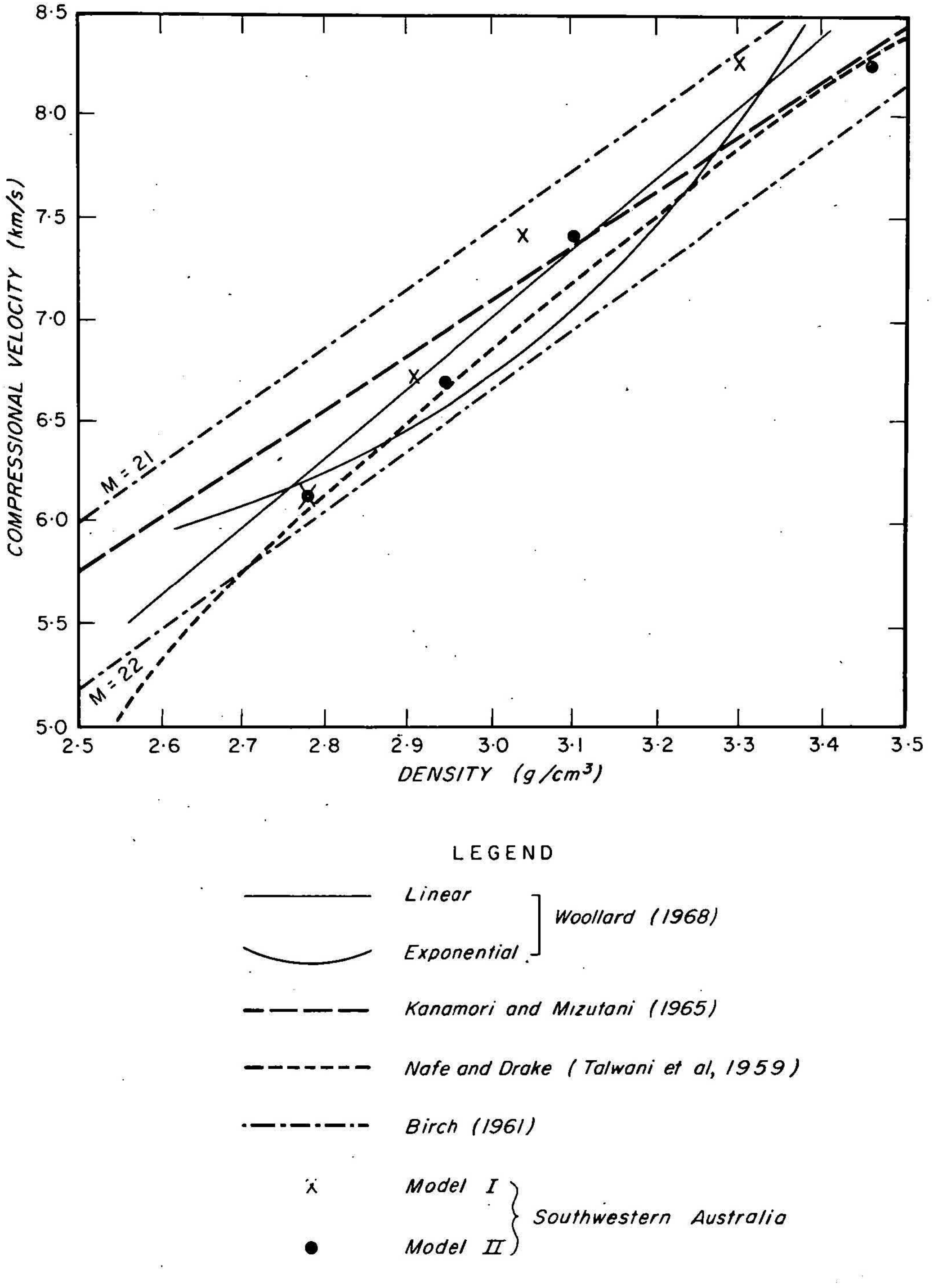


Fig 8 DENSITY - VELOCITY RELATIONS

WA/B3-26A

GEOTRAVERSE, W.A.

To accompany Record No. 1973 / 63

GEOTRAVERSE W.A.

To accompany Record No. 1973 / 63

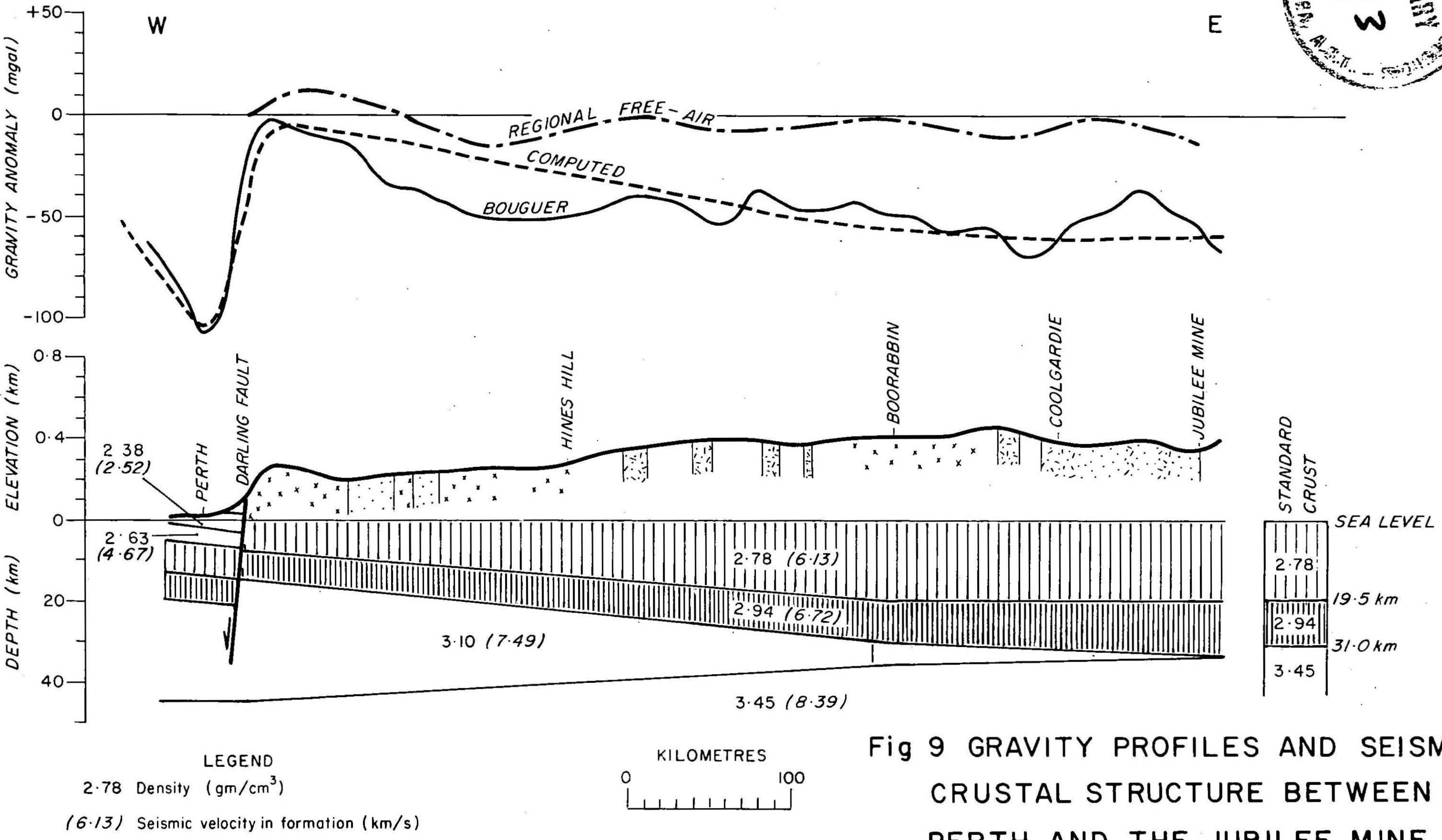


Fig 9 GRAVITY PROFILES AND SEISMIC CRUSTAL STRUCTURE BETWEEN PERTH AND THE JUBILEE MINE

WA/B3-29A

GEOTRAVERSE W.A.

To accompany Record No. 1973 / 63

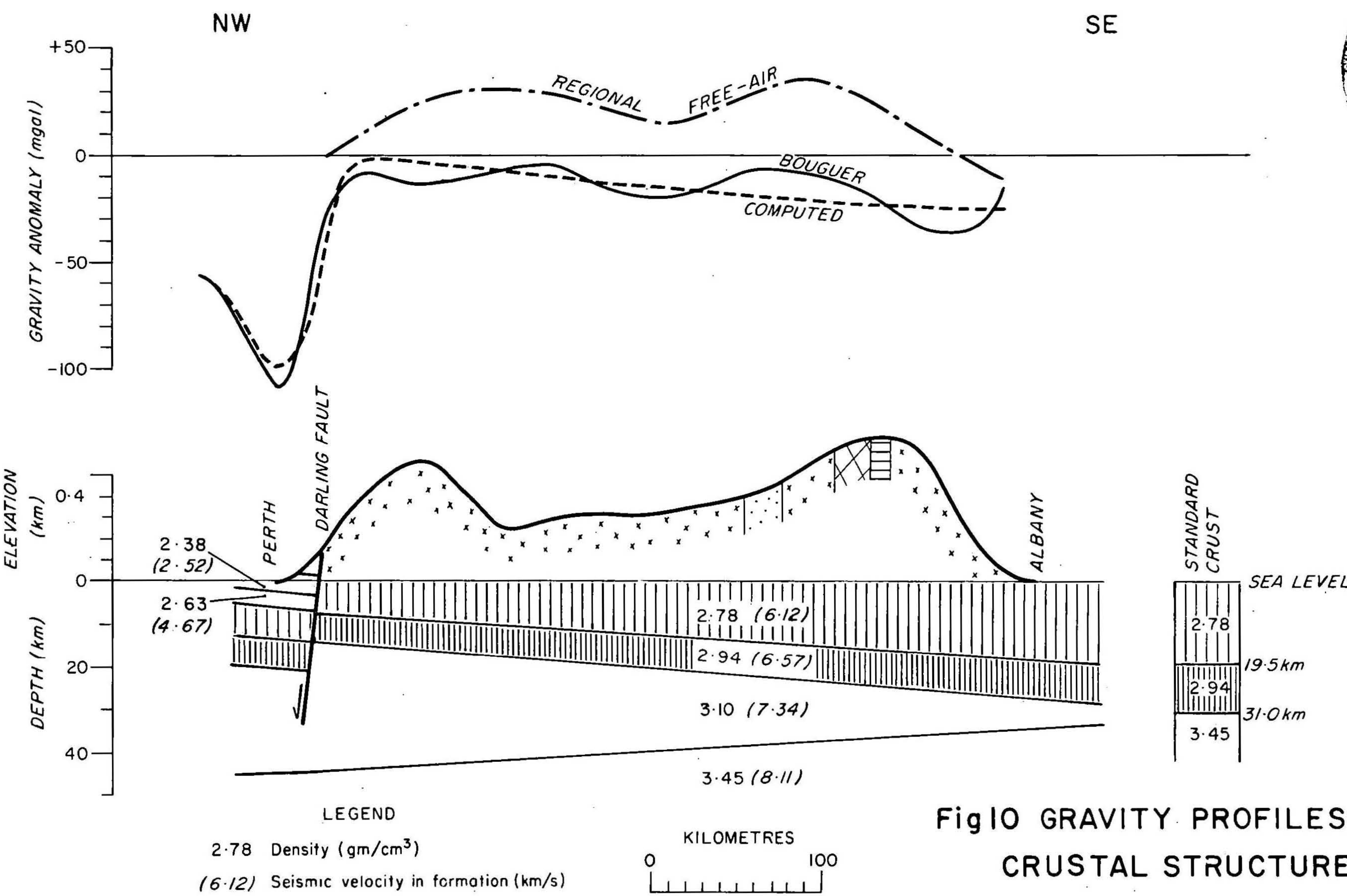


Fig 10 GRAVITY PROFILES AND SEISMIC CRUSTAL STRUCTURE BETWEEN PERTH AND ALBANY

WA/B3-31A

GEOTRAVERSE W.A.

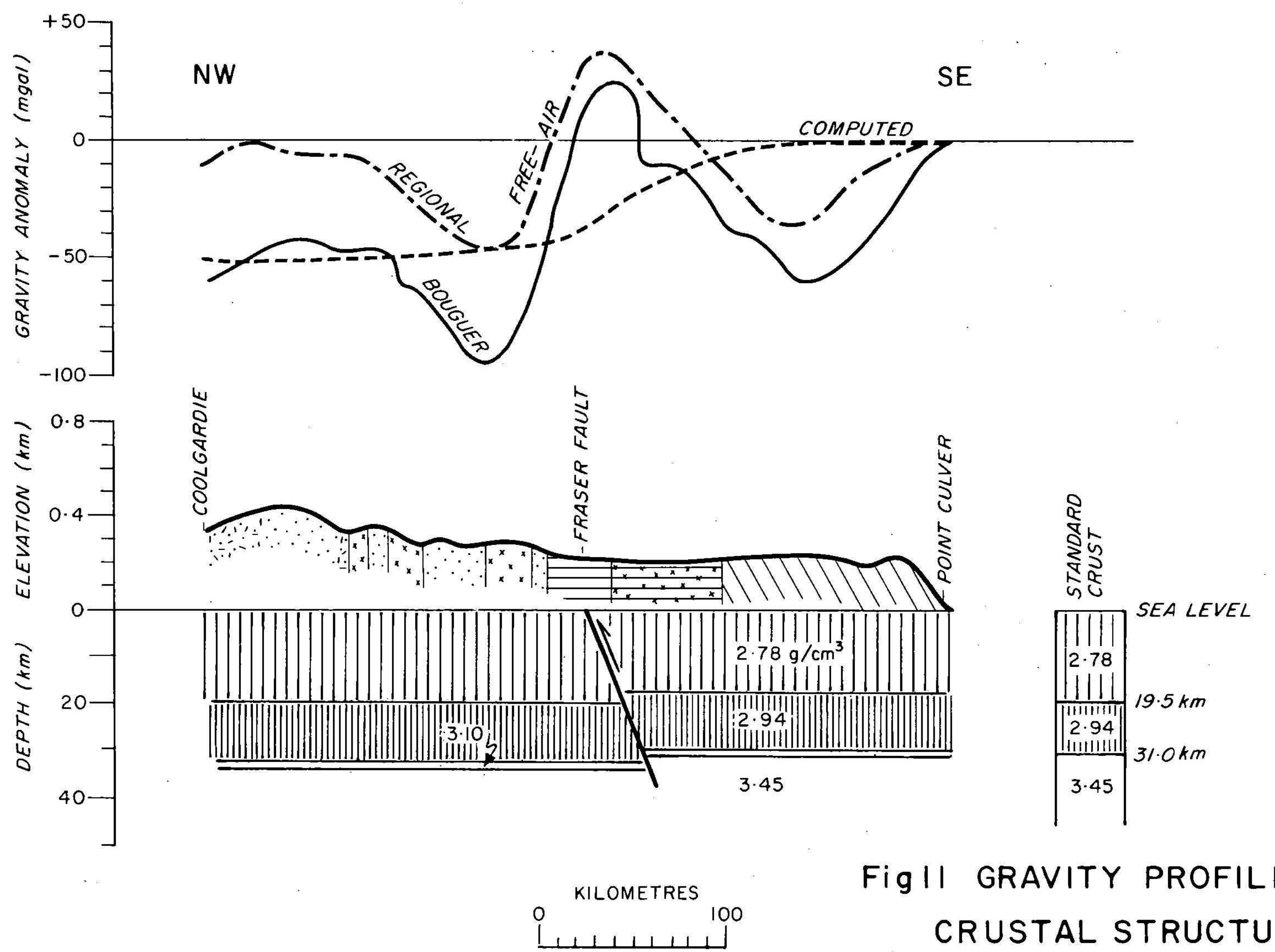
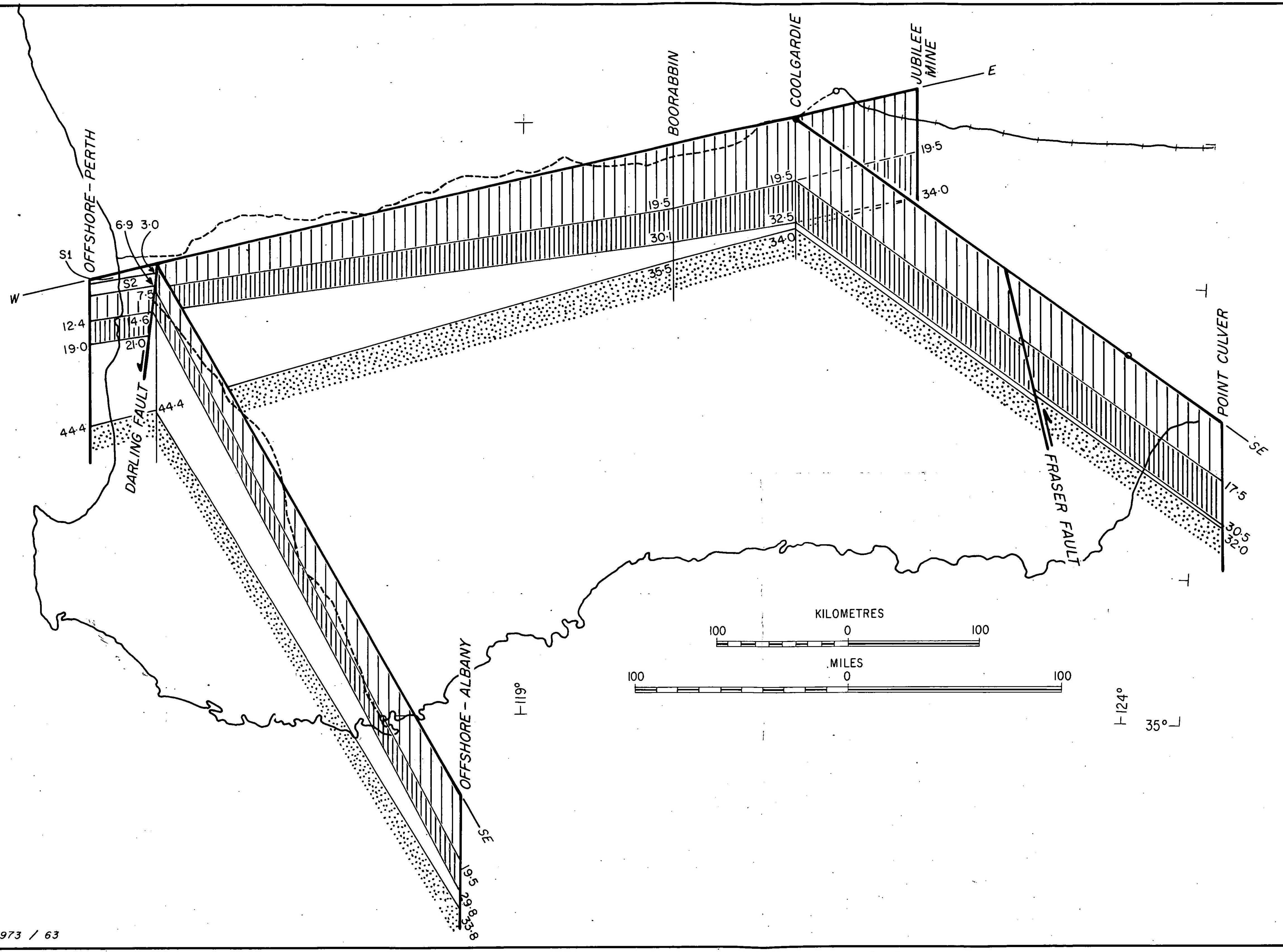


Fig 11 GRAVITY PROFILES AND SEISMIC CRUSTAL STRUCTURE BETWEEN COOLGARDIE AND POINT CULVER

To accompany Record No. 1973 / 63

WA/B3-30A



	VELOCITY KM/SEC	DENSITY GM/CM^3
S1 SEDIMENTS	2·52	2·38
S2 SEDIMENTS	4·67	2·63
CRUST LAYER 1	6·12	2·78
CRUST LAYER 2	6·67	2·94
CRUST LAYER 3	7·42	3·10
MANTLE	8·25	3·45

DEPTHS SHOWN ARE IN KILOMETRES

Fig 12 CRUSTAL STRUCTURE IN A FENCE DIAGRAM

To accompany Record No. 1973 / 63

GEOTRAVERSE W.A.

WA/B3-32