Engineering Section

6727-IV

Engineering Division

REPT.BK.NO. 76/48

THE PALLAMANNA FAULT - OUTLINED BY GEOPHYSICAL METHODS

Co. Sturt, Hd. Mobilong

- Monarto Development Commission -

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Department of Mines

South Australia ——

72-17a

DEPARTMENT OF MINES

SOUTH AUSTRALIA

GEOLOGICAL SURVEY BRANCH

GEOPHYSICS DIVISION

THE PALLAMANNA FAULT - OUTLINED BY GEOPHYSICAL METHODS

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- Monarto Development Commission -

by

R.G. NELSON,
GEOPHYSICIST,

1st April, 1976

Rept.Bk.No. 76/48
G.S. No. 5124
D.M. No. 1119/74

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76-197	Pallamanna Fault Location of traverses/gravity contours.	1:10 000
76-199	Gravity profiles - lines 1, 2, 3, 4, and 5.	1:10 000
76-198	Seismic refraction profiles.	1:10 000
S12123	Adjustment of gravity network.	Diag.
S12124	Line 3 - gravity interpretation.	As shown.
S12125	Line 4 - gravity interpretation.	As shown.
S12122	Trace of fault inferred from geophysical evidence.	1:50 000

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Co. Sturt, Hd. Mobilong

- Monarto Development Commission -

ABSTRACT

The Pallamanna Fault is a Palaeozoic feature on the western margin of the Murray Basin neary Murray Bridge. Geophysical methods were used to delineate it and to estimate its throw. The results suggest that the fault zone itself is steeply dipping (70° to 80°) to the east but that the associated fault scarp has been eroded, in some places more severely than in others. The throw appears to be of the order of 100 m.

INTRODUCTION

At the request of the Monarto Development Commission on the advice of Coffey and Hollingsworth Pty. Ltd., a geophysical programme was undertaken to map the Pallamanna Fault at the eastern edge of the Monarto area.

The Pallamanna Fault is considered to act to a limited extent as a line source of recharge to the aquifers between the fault and the River Murray (Bowering, 1975). Increased run-off via the Rocky Gully and Preamimma Creeks from the Monarto area is expected as urban development takes place, and holding reservoirs may have to be constructed on these creeks. Therefore, the position of the fault is of considerable importance.

Gravity measurements were made initially to outline the general strike and position of the fault. Seismic refraction traverses along the two creeks helped locate the fault positions on these creeks more accurately. Later, electrical resistivity measurements served to corroborate the seismic and gravity results.

GEOLOGY

The Pallamanna Fault is a Palaeozoic feature running north-south along the western margin of the Murray Basin near Murray Bridge. It has been formed by downfaulting of a basement block. The downthrow is to the east, where transgressive limestones of the Mannum Formation (Tertiary) and Recent sands and clay cover the basement rocks. The basement rocks exposed on its western side consist of migmatites, schists, gneisses and amphibolites of the Cambrian Kanmantoo Group.

The limited borehole information available indicates that the downthrow of the fault is in excess of 50 m.

GEOPHYSICAL METHODS USED

(1) Gravity

Five gravity traverses (see Plan No. 76-197) were made between and nearby the Rocky Gully and Preamimma Creeks in the vicinity of the fault. All traverses were levelled and tied to benchmarks 7964, 7965, 6727/1945 and 6727/1725. The datum used is MSL1 (Port Adelaide). The traverses were plotted on sheet Nos. 6727/3, /8 and /13 of the S.A. 1:10 000 orthophoto series (South Aust. Dept. of Lands, 1974) for horizontal control. Station spacing was 100 m.

The gravity meter used was a Sharpe Prospector serial No. 201 with a calibration constant of 0.0999(3) mgals/div. (18.8.75). The ends of traverses were tied together and thence to the Murray Bridge gravity station, 68 Io.0017, for which the following data are available:

elevation	=	20.71 m
observed gravity	=	979737.61 mgals
latitude	=	$35^{o}07'06''$

The data were corrected for drift and network errors were adjusted by a process due to Smith (1951) (see Plan No. S12123).

Bouguer gravity values were derived from these data by applying the elevation, Bouguer and latitude corrections. Because of limitations in time, terrain corrections were not made: these may be of some significance in the Rocky Gully Creek area.

A density of 2.74 gms/cc was assumed for the Kanmantoo Group metasediments, and for the Tertiary limestones and more recent sediments, a density of 1.9 gms/cc.

Tables of the Bouguer gravity values appear in Appendix 1.

(2) Seismic Refraction

Two traverses were made, one along each creek bed. Each traverse consisted of two spreads each of 24 geophone stations at 10 m intervals, the traverse length being therefore 460 m. Shots were fired at intervals along each spread to give a multiplicity of travel times for each geophone station. Seismic records were timed to the nearest 0.5 msec for first arrivals of energy and results were plotted on time-distance graphs. These were analysed to determine the various refractors present, their velocities, and the depths according to time at which they lie beneath each geophone station. A time-depth section was produced, and this was converted to a depth section using the measured velocities.

(3) Electrical Resistivity

In order to resolve certain ambiguities in the seismic section, particularly concerning a possible 1900 m/s refractor on

Preamimma Creek, expanding depth probes were made downstream from the fault, one near each creek. The Schlumberger electrode array was used.

Although the data were poor, these provided some confirmation of basement depths fro the seismic and gravity work.

RESULTS

(1) Gravity

All gravity profiles show the shape characteristic of a fault (see Plan No. 76-199), although in some cases the slope on the upthrow side shelves off more slowly, implying a possible erosion of the fault scarp back from the fault itself. Estimates of the maximum value of the horizontal gradient (see Appendix 2) were used to locate the trace of the fault at ground surface. Estimates of the fault parameters (dip, depth, throw) were made from the gravity profiles. The theoretical gravity due to models derived from these was compared with the original data, and adjustments to give a better fit were made where necessary (see Plan Nos. S12124 and S12125).

The results indicate that there is a thin cover (0 m to 5 m) of less dense material (soil or weathered rock) on the upthrow side; that the fault zone itself plunges at a steep angle (70° to 80° to the east), but that the fault scarp has been eroded back in places; and that the total depth to basement on the downthrow side is of the order of 100 m.

(2) Seismic Refraction

The seismic depth profiles are shown in Plan No. 76-198.

Other refractors encountered have velocities in the following ranges:

TABLE 1

Group	Velocity Range
I	300 - 700 m/s
II	850 - 1 000 m/s
III	1 100 - 1 500 m/s
IV	1 850 - 1 950 m/s
V	3 300 - 3 600 m/s

The boundaries between refractors from Groups I and II are indistinct: the refractors themselves probably consist of soils, sands and clays of varying degrees of compaction and moisture content. Group III refractors are undoubtedly weathered basement rocks, occurring as they do over outcrops of basement material. Group IV refractors cannot be identified with certainty: they may either be water-saturated unconsolidated sediments, or limestones of the Mannum Formation (whose velocities have been found to be in the range 1 300 - 1800 m/s elsewhere - Nelson (1973)), or both. Group V refractors are certainly unweathered rocks from the Kanmantoo Group.

Rocky Gully Creek

The initial downthrow is well defined on the seismic profile. A sharp drop of 30 m in basement level occurs at the western end of the traverse, with a more gradual slope thereafter to 90 m at the eastern end of the traverse. Up to 10 m of weathering (1 440 m/s refractor) occurs where basement rocks outcrop. This may be expected to continue beneath the 1 955 m/s layer on the downfaulted side, but it cannot be detected from first seismic arrivals.

Preamimma Creek

There is no abrupt change in bedrock configuration over this traverse. Rather, the bedrock slopes downward at angles generally of less than 20°. This may be due to erosion of the fault scarp, in which case the fault itself may be further downstream.

Note the 1 850 m/s layer (Group IV). In fact, this is represented by only a few points on the time-distance graphs and is very hard to recognise (were it any thinner, it would form a "blind zone"). However, as seen on the section, its thickness may be considerable. The travel times for the section shown have been calculated using ray path methods and match the actual travel times very well, affording some confirmation of the layer's existence. The electrical resistivity tends to corroborate this.

(3) Electrical Resistivity

Rocky Gully Creek

Interpretation of the depth probe here gives this distribution:

Resistivity	Thickness	Depth	Rock Type
43 ohm-m	0.84 m	0 m	Dry to moist sandy soil and/or calcrete corresponding to velocity groups I and II.
28 "	19.3 m	0.8 m	
2.9 "	82.3 m	20.1 m	Mannum Formation? Velocity group IV.
34.5 "	-	102.4 m	Kanmantoo Group - basement. (may be weathered)

This implies that bedrock lies at about 102 m, but the effects of electrical anisotropy may reduce this estimate by as much as 20%, to 82 m.

The 2.9 ohm-metre layer associated with the 1 955 m/s layer suggests a high porosity material saturated with saline waters (8 000 - 10 000 ppm* possibly).

Preamimma Creek

The following resistivity distribution is interpreted:

Resistivity	Thickness	Depth	Rock types
22 ohm-m	1.35 m	0 m	Dry to moist sandy soil and/or calcrete.
2.2 "	2.9 m	1.4 m	Clay?
8.8 "	114.7 m	4.3 m	Mannum Formation?
infinite	-	119.0 m	Kanmantoo Group rocks.

This implies that basement lies at 119 m, an estimate which reduces to 95 m after applying a correction of 20%, for anisotropy.

The 8.8 ohm-metre layer suggests that groundwater is less saline here (possibly 5000 ppm*).

CONCLUSIONS

The trace of the fault at ground level has been mapped from measurements of the maximum horizontal gravity gradient and by seismic observations.

(1) Gravity measurements imply that the fault

(a) has a throw of the order of 90-100 m,

(b) plunges at angles of 70-80° to the east,

(c) has a scarp which has been eroded back in places.

(2) Seismic measurements imply that the fault, over the traverses made

(a) has a throw of 70 m to 90 m,

(b) has a scarp which has been eroded back at Preamimma Creek, but which is still quite sharp at Rocky Gully Creek,

* Estimates of salinity based on work done on limestones in the southeast of South Australia - Nelson, 1972. These tend to agree with Bowering's work (Bowering, 1975).

(c) at depths of 20-40 m on its downthow side a 1 900 m/s layer exists which may be the Mannum Formation.

(3) Electrical resistivity measurements indicate a throw of up to 120 m, but the effects of anisotropy may reduce this estimate to 95 m.

The 1 900 m/s seismic refractor has been equated to layers of low resistivity, indicating that groundwater is quite saline. The salinity appears to be greater in the vicinity of the fault at Rocky Gully Creek than at Preamimma Creek.

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1st April, 1976
RGN:ST

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APPENDIX 1

TABLES OF BOUGUER GRAVITY VALUES

(Bouguer density used is 2.74 gms/cc)

PALLAMANNA FAULT

LINE 1

Station	Latitude	Longitude	Elevation (m)	Observed gravity (mgals)	Bouguer gravity (mgals)
00	35°06'51"	139°13'21"	75.078	979730.84	- 9.83
1	06'52"	13'24"	75.765	730.61	- 9.95
2	06'54"	13'28"	74.709	730.62	-10.20
3	06'56"	13'31"	67.643	731.87	-10.36
4	06'57"	13'35"	56.181	733.99	-10.49
5	06'59"	13'39"	51.285	734.88	-10.60
6	07'00"	13'42"	45.235	735.95	-10.71
7	07'02"	13'45"	42.095	736.29	-11.03
8	07'04"	13'49"	41.977	736.34	-11.06
9	07'05"	13'52"	42.978	735.60	-11.62
10	07'07"	13'56"	36.478	736.15	-12.38
11	07'08"	13'59"	34.298	736.61	-12.37
12	07'10"	14'03"	32.403	737.00	-12.38
13	07'10"	14'07"	30.097	737.37	-12.46
14	07'10"	14'11"	27.269	737.92	-12.47
15	07'10"	14'15"	24.791	738.50	-12.37
16	07'11"	14'19"	22.717	738.87	-12.42
17	07'10"	14'23"	20.346	739.34	-12.39
18	07'09"	14'27"	18.209	739.56	-12.56
19	07'08"	14'31"	17.417	739.44	-12.80
20	07'08"	14'36"	16.816	379.22	-13.14
21	07'07"	14'40"	17.819	738.76	-13.39

PALLAMANNA FAULT

LINE 2

Station	Latitude	Longitude	Elevation (m)	Observed gravity (mgals)	Bouguer gravity (mgals)
00	35°06'34"	139°13'20"	40.693	979737.18	- 9.75
1	06'34"	13'23"	38.716	737.36	- 9.95
2	06'33"	13'27"	36.677	737.66	-10.03
3	06'33"	13'31"	34.657	737.64	-10.44
4	06'33"	13'35"	32.967	737.93	-10.48
5	06'33"	13'39"	31.931	738.01	-10.60
6	06'33"	13'42"	31.100	738.08	-10.70
7	06'33"	13'46"	29.715	737.97	-11.07
7.5	06'33"	13'48"	-	737.53	-11.68
8	06'34"	13'50"	28.070	737.19	-12.19
9	06'34"	13'54"	26.334	737.28	-12.43
10	06'35"	13'59"	24.755	737.61	-12.44
11	06'36"	14'03"	23.543	737.97	-12.34
12	06'37"	14'07"	22.372	738.38	-12.17
13	06'38"	14'12"	21.254	738.66	-12.14
14	06'39"	14'16"	20.058	738.91	-12.14
15	06'39"	14'20"	19.022	739.07	-12.18
16	06'40"	14'25"	17.926	739.28	-12.21
17	06'41"	14'29"	16.841	739.38	-12.34
18	06'42"	14'33"	15.737	739.53	-12.43
19	06'43"	14'37"	14.826	739.58	-12.58
20	06'43"	14'42"	14.201	739.55	-12.73
21	06'45"	14'46"	13.586	739.71	-12.74
22	06'45"	14'50"	12.981	739.80	-12.77
23	06'46"	14'54"	12.359	739.81	-12.90
24	06'47"	14'59"	11.741	739.88	-12.97

PALLAMANNA FAULT

LINE 3

Station	Latitude	Longitude	Elevation (m)	Observed gravity (mgals)	Bouguer gravity (mgals)
00	35°05'48"	139°13'16"	65.230	979731.73	- 9.37
1	05'49"	13'20"	66.468	731.45	- 9.43
2	05'50"	13'24"	66.276	730.82	-10.12
3	05'52"	13'28"	66.556	730.83	-10.11
4	05'53"	13'32"	63.821	731.07	-10.41
5	05'54"	13'36"	58.417	731.64	-10.92
6	05'56"	13'39"	52.668	732.20	-11.52
7	05'58"	13'41"	46.908	732.40	-12.48
8	06'01"	13'44"	42.634	733.07	-12.71
9	06'03"	13'47"	38.497	733.99	-12.46
10	06'05"	13'50"	34.260	734.93	-12.57
11	06'07"	13'53"	30.140	735.90	-12.45
12	06'10"	13'55"	26.855	736.82	-12.23
13	06'12"	13'58"	24.813	737.36	-12.14
14	06'14"	14'01"	23.735	737.79	-11.96
15	06'17"	14'04"	23.556	737.91	-11.94
16	06'19"	14'07"	23.465	737.98	-11.94
17	06'21"	14'09"	24.281	737.72	-12.09
18	06'24"	14'12"	23.716	737.78	-12.20
19	06'26"	14'15"	21.333	738.19	-12.30
20	06'27"	14'18"	18.391	738.86	-12.23
21	06'27"	14'22"	16.052	739.39	-12.16
22	06'28"	14'26"	14.093	739.60	-12.34
23	06'29"	14'30"	15.046	739.41	-12.37

PALLAMANNA FAULT

LINE 4

Station	Latitude	Longitude	Elevation (m)	Observed gravity (mgals)	Bouguer gravity (mgals)
00	35°03'25"	139°12'03"	76.263	979726.62	- 8.97
1	03'23"	12'06"	74.637	726.78	- 9.08
2	03'20"	12'08"	72.387	726.97	- 9.26
3	03'18"	12'11"	71.346	727.03	- 9.35
4	03'15"	12'14"	71.314	726.99	- 9.33
5	03'13"	12'16"	70.454	727.22	- 9.22
6	03'10"	12'19"	69.954	726.97	- 9.49
7	03'08"	12'21"	69.338	726.50	-10.03
8	03'06"	12'24"	66.606	726.25	-10.76
9	03'03"	12'27"	64.472	725.40	-11.96
10	03'01"	12'29"	62.838	725.14	-12.49
11	02'58"	12'32"	61.553	725.18	-12.63
12	02'56"	12'35"	60.531	725.35	-12.60
13	02'54"	12'38"	59.449	725.59	-12.53
14	02'53"	12'41"	58.463	725.87	-12.42
15	02'52"	12'44"	57.648	726.10	-12.32
16	02'52"	12'48"	56.923	726.17	-12.40
17	02'51"	12'52"	56.448	726.21	-12.42
18	02'51"	12'56"	56.263	726.19	-12.47
19	02'51"	13'00"	56.803	726.00	-12.57

PALLAMANNA FAULT

LINE 5

Station	Latitude	Longitude	Elevation (m)	Observed gravity (mgals)	Bouguer gravity (mgals)
00	35°03'57"	139°12'06"	88.551	979725.04	- 8.92
1	03'59"	12'09"	89.919	724.68	- 9.07
2	04'01"	12'12"	89.502	724.71	- 9.17
3	04'03"	12'16"	88.129	724.88	- 9.31
4	04'04"	12'19"	87.081	725.03	- 9.38
5	04'06"	12'23"	84.966	725.48	- 9.39
6	04'08"	12'26"	83.190	725.79	- 9.47
7	04'10"	12'29"	83.602	725.72	- 9.51
8	04'12"	12'32"	86.965	725.03	- 9.60
9	04'14"	12'36"	87.409	724.85	- 9.73
10	04'16"	12'39"	85.456	725.13	- 9.88
11	04'18"	12'42"	83.618	725.43	- 9.99
12	04'20"	12'46"	81.282	725.76	-10.16
13	04'22"	12'49"	78.763	726.19	-10.26
14	04'23"	12'52"	76.230	726.40	-10.56
15	04'26"	12'56"	73.296	726.83	-10.78
16	04'27"	12'59"	70.644	727.06	-11.08
17	04'29"	13'02"	67.965	727.39	-11.32
18	04'31"	13'06"	65.138	727.64	-11.66
19	04'33"	13'09"	62.543	727.83	-12.02
20	04'35"	13'12"	59.708	727.94	-12.51
21	04'37"	13'15"	56.639	728.33	-12.75
22	04'39"	13'19"	52.767	729.11	-12.78
23	04'41"	13'22"	50.727	729.57	-12.76
24	04'42"	13'26"	48.819	729.99	-12.73
25	04'44"	13'29"	45.749	730.75	-12.62
26	04'46"	13'32"	43.302	731.35	-12.53
27	04'48"	13'36"	41.178	731.76	-12.58
28	04'50"	13'39"	39.577	732.14	-12.57
29	04'52"	13'42"	38.596	732.30	-12.64
30	04'54"	13'45"	37.887	732.47	-12.66
31	04'56"	13'49"	37.444	732.64	-12.61

APPENDIX 2

FORMULA USED TO ESTIMATE HORIZONTAL GRADIENT OF GRAVITY, dg/dx.

FORMULA USED TO ESTIMATE HORIZONTAL GRADIENT OF GRAVITY, dg/dx.

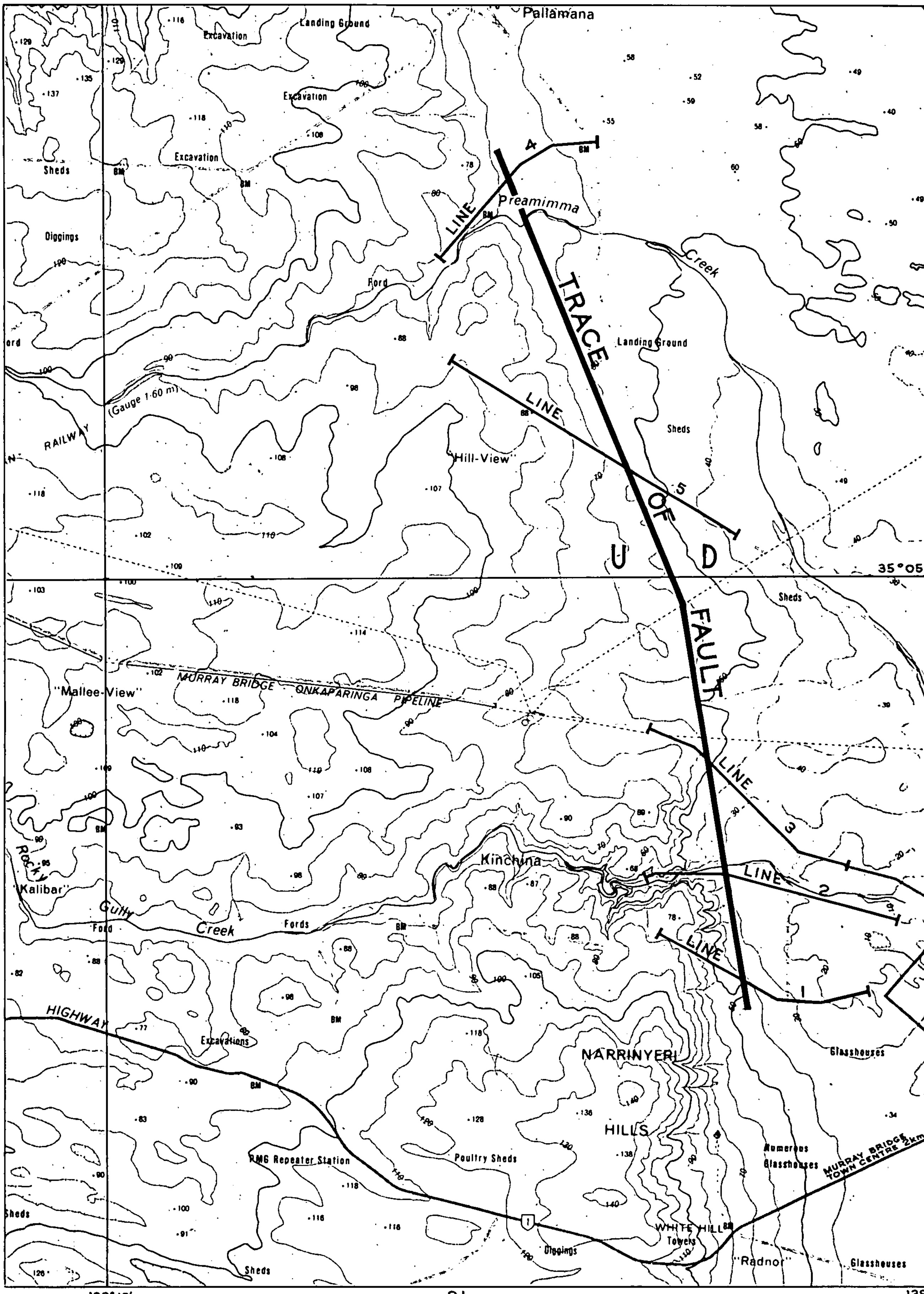
Suppose data are equispaced with a station spacing of X metres. Since the data are equispaced, orthogonal polynomials can be used to fit (in the least squares sense) a parabolic function to a set of data points. It can be shown that for a set of 5 data points:

$$g^{-2},\ g^{-1},\ g_0,\ g_1,\ g_2,\ \text{(mgals)}$$

the value

$$D = (-0.2g_{-2} - 0.1g_{-1} + 0.1g_1 + 0.2g_2)/x$$

is an estimate of the first derivative, dg/dx, at the point, g_0, in mgals/metre.



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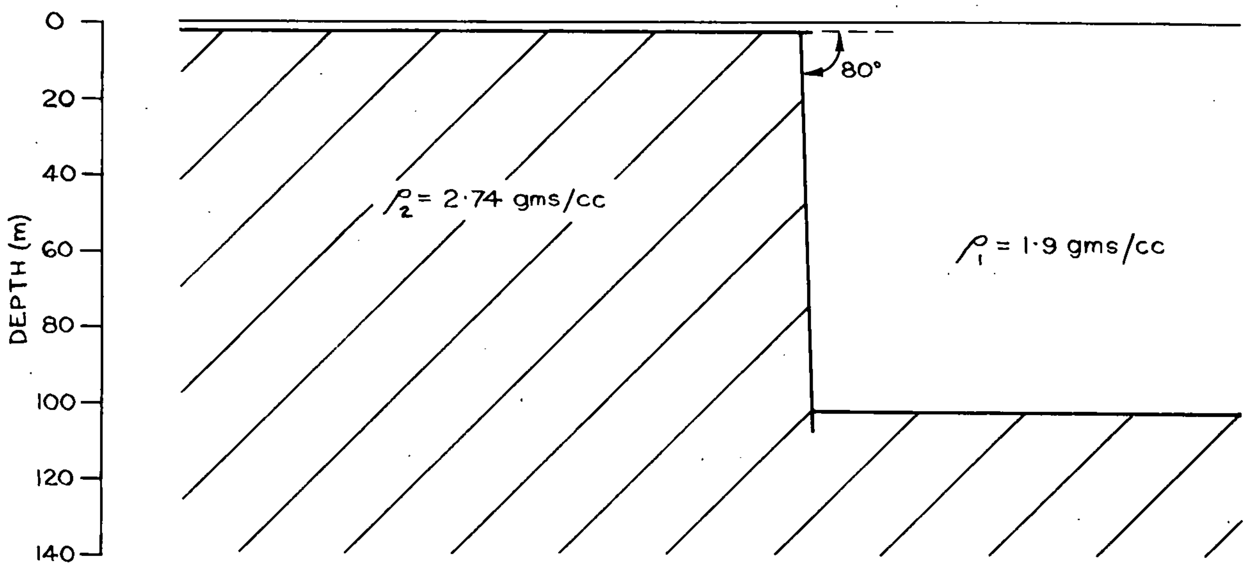
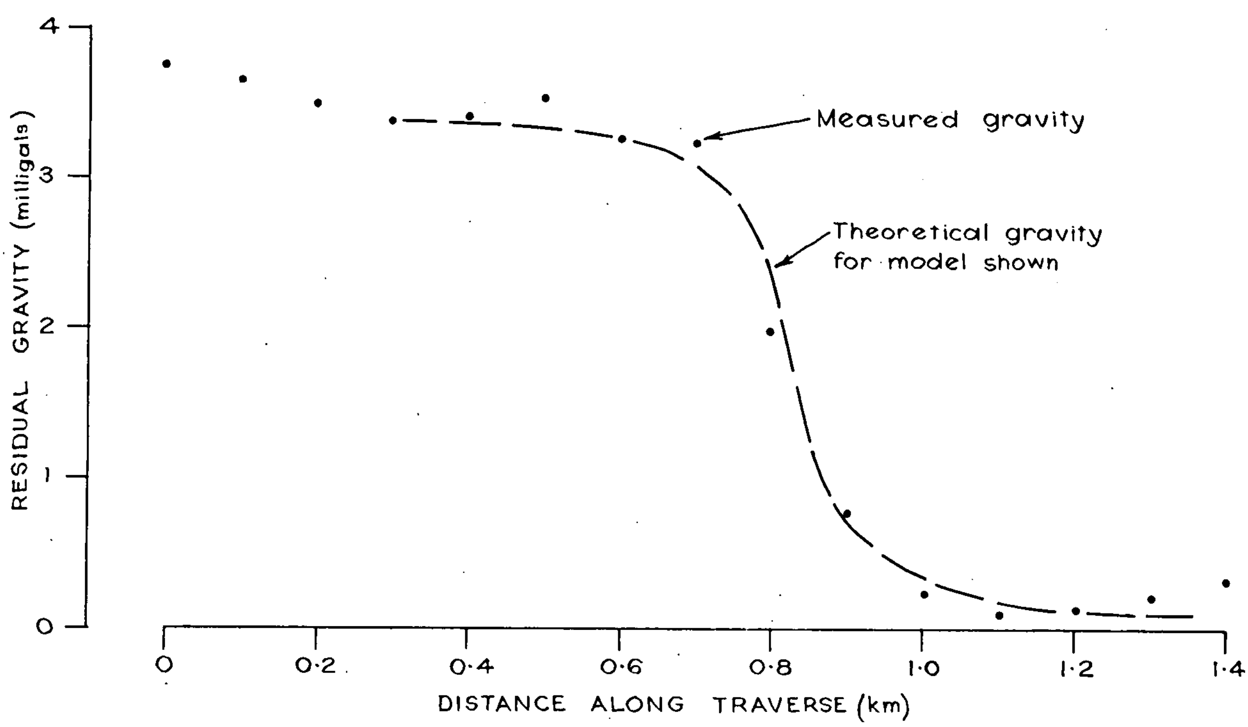
COMPILED: R.G.Nelson	PALAMANNA FAULT TRACE OF FAULT INFERRED FROM GEOPHYSICAL EVIDENCE	DATE: 1·4·76
DRN: A.F. CKD.		PLAN NUMBER: S12122





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Drn. A.F. Ckd	GRAVITY INTERPRETATION LINE 4	Drg. No. S12125

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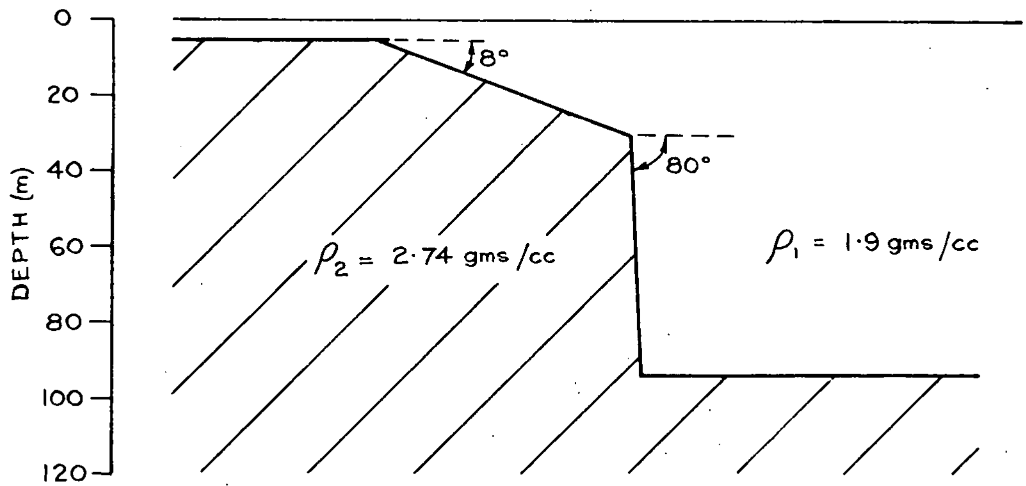

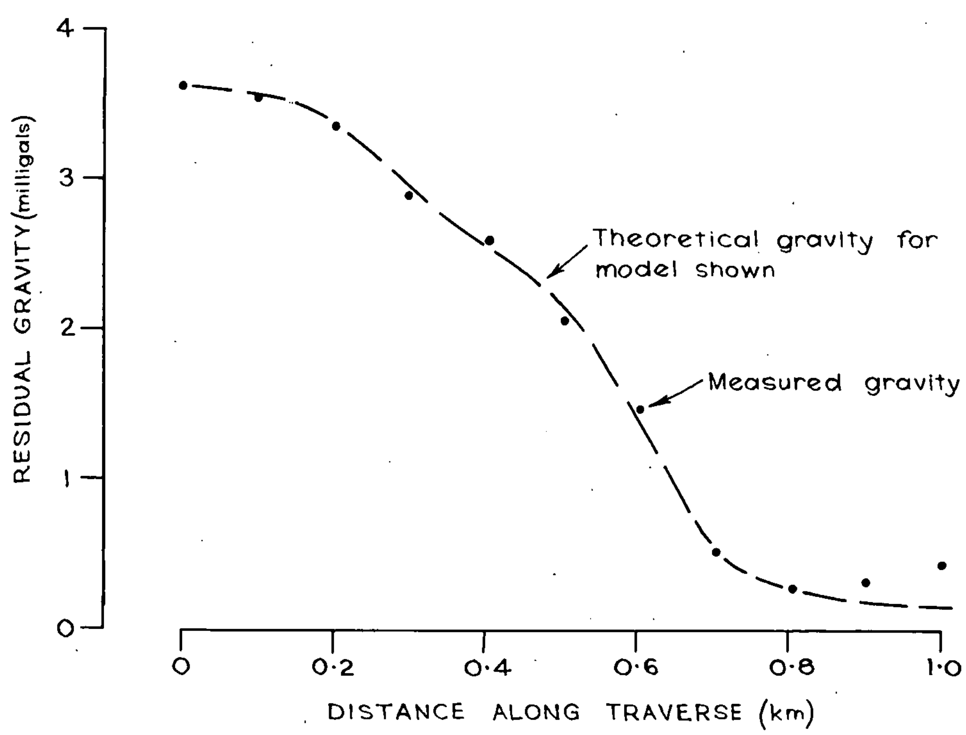

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Compiled R.G.N.		PALLAMANNA FAULT	Date : 23-2-76
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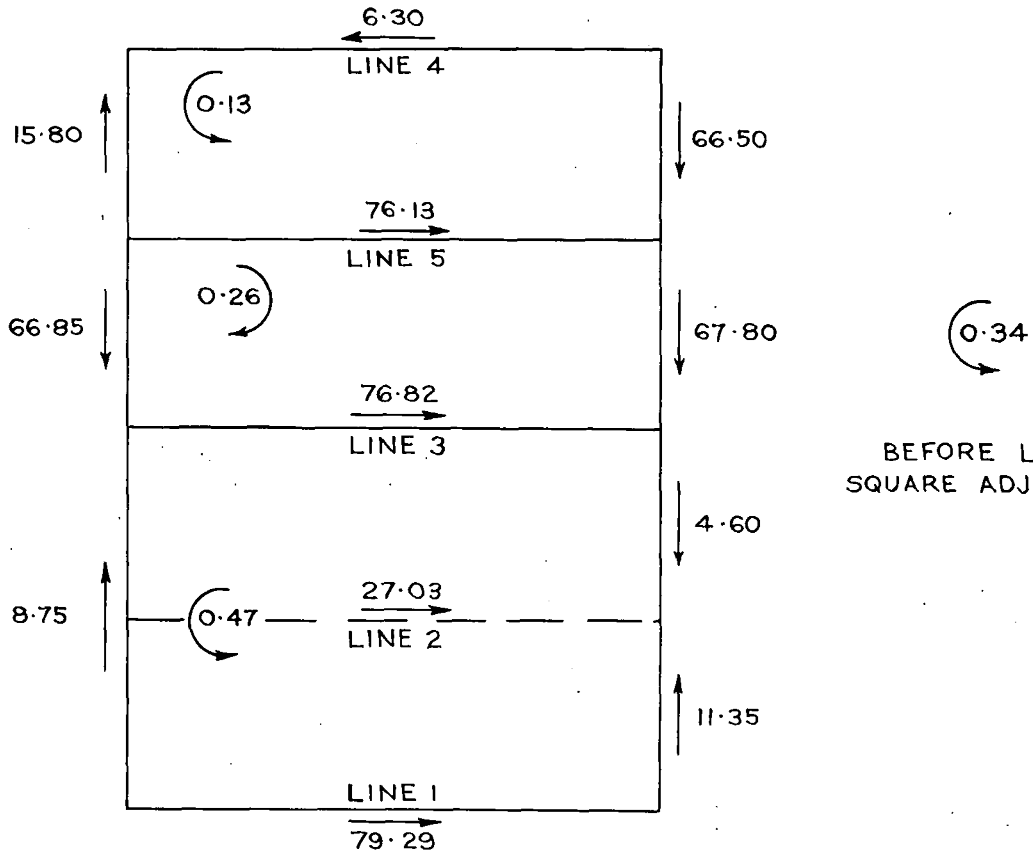
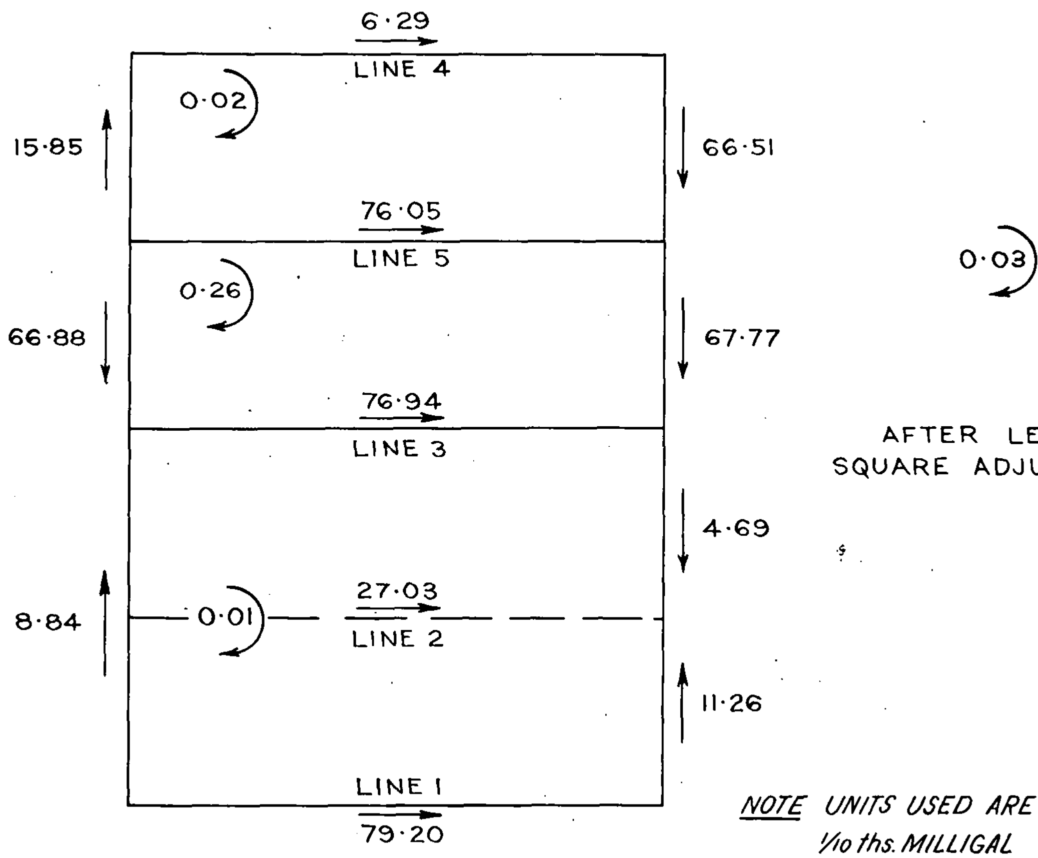


BEFORE LEAST SQUARE ADJUSTMENT



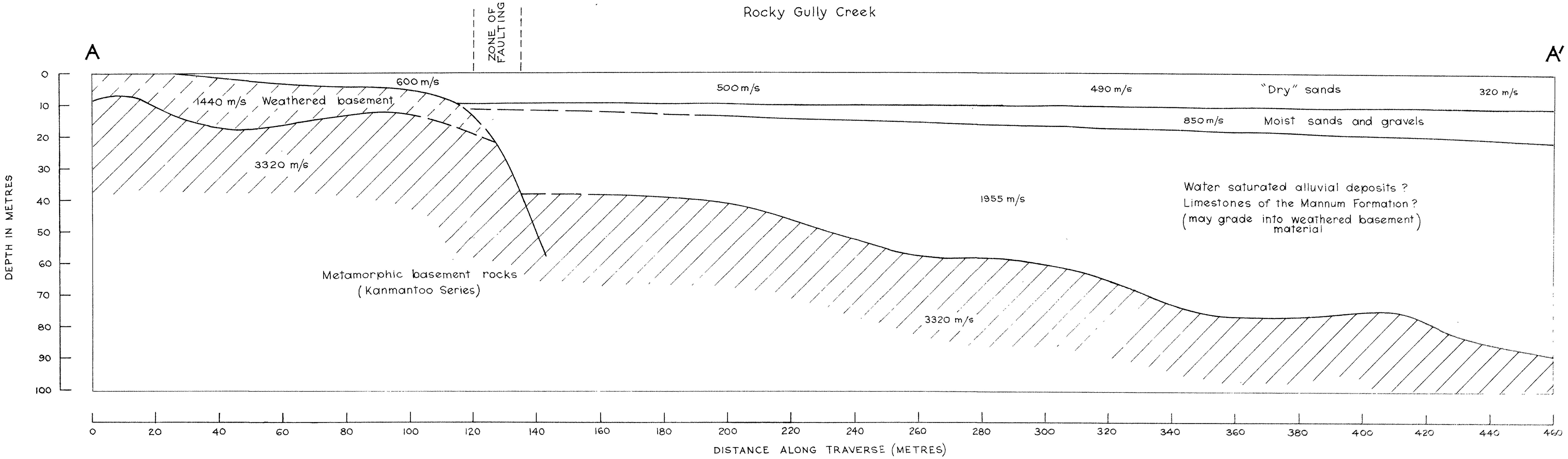
AFTER LEAST SQUARE ADJUSTMENT

<u>NOTE</u> UNITS USED ARE IN 1/10 ths. MILLIGAL

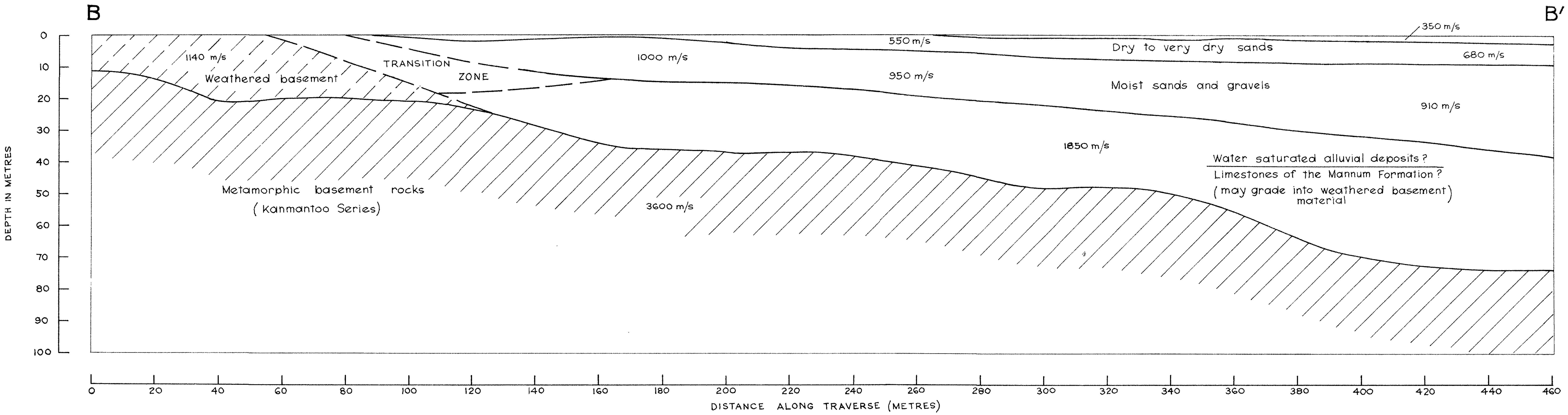
GEOPHYSICAL SERVICES SECTION	DEPARTMENT OF MINES — SOUTH AUSTRALIA	Scale :
Compiled : R.G.N.	PALAMANNA FAULT ADJUSTMENT OF GRAVITY NETWORK	Date : 16 - 3 - 76
Drn. A.F. Ckd		Drg. No. S12123

750—8.74 F332 O

TRAVERSE A–A′
Rocky Gully Creek



TRAVERSE B – B′



DEPARTMENT OF MINES – SOUTH AUSTRALIA

PALLAMANNA FAULT
SEISMIC REFRACTION PROFILES

GEOPHYSICAL SERVICES SECTION	R. G. Nelson GEOPHYSICIST	**Compiled** R.G.N.	**Scale :** 1:10000
			Date : 16-3-76
Director of Mines		**Drn.** A.F.	**Drg. No.** 76-198
		Ckd.	

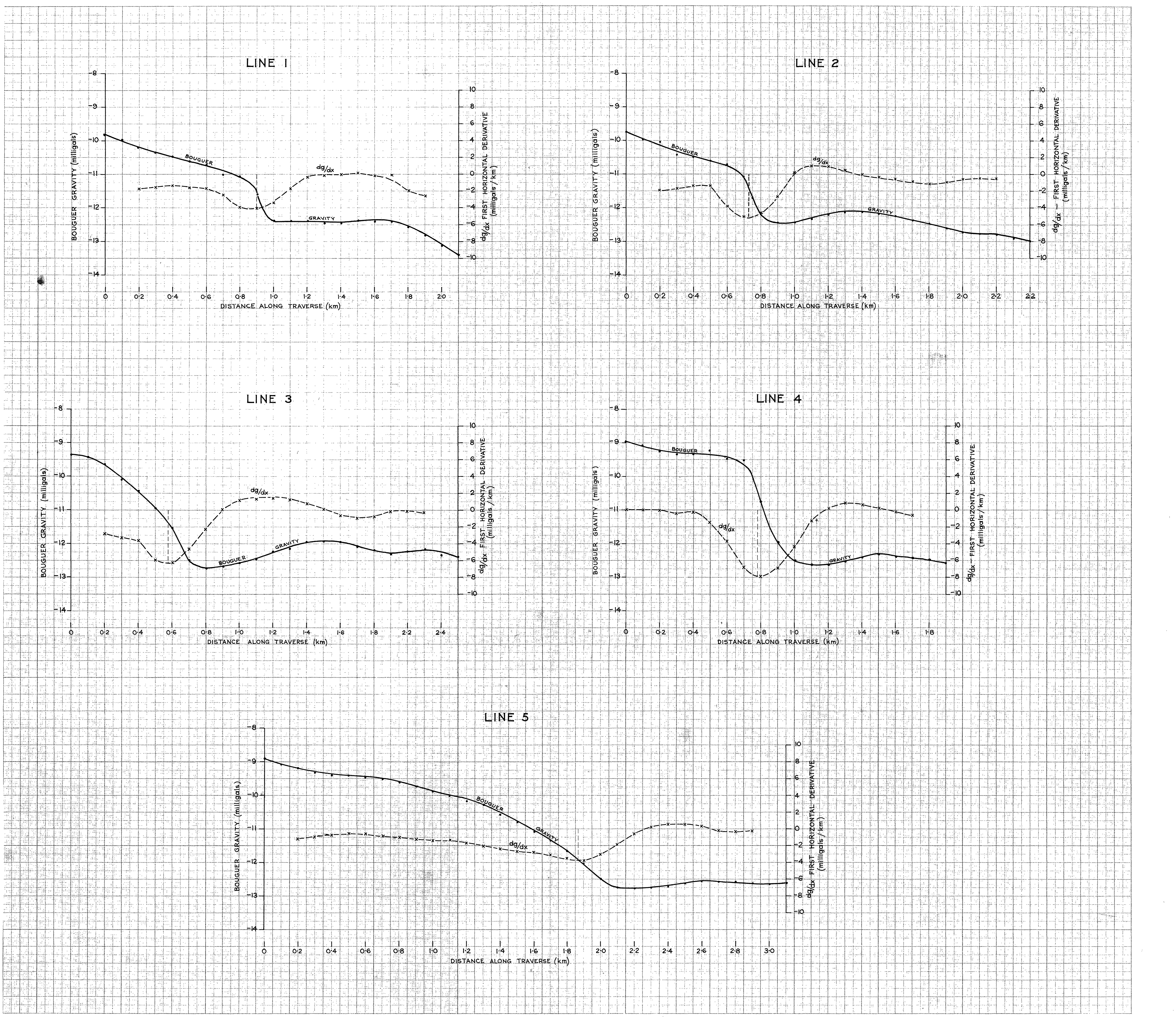
1000-9.73 E407

Seismic refraction traverse . . . . A – – – – – A′

Gravity traverse . . . . LINE 2

Gravity contour (interval 0·2 milligals) . . . . —9·0—

DEPARTMENT OF MINES–SOUTH AUSTRALIA				
PALLAMANNA FAULT				
TRAVERSE LOCATIONS AND GRAVITY CONTOURS				
GEOPHYSICAL SERVICES SECT.	COMPILED: R.G.N.	DRN: A.F.	SCALE: 1:10 000	PLAN NUMBER
DIRECTOR OF MINES		CKD:	DATE:	76–197



DEPARTMENT OF MINES — SOUTH AUSTRALIA

PALLAMANNA FAULT

GRAVITY RROFILES LINES 1, 2, 3, 4, AND 5

GEOPHYSICAL SERVICES SECTION	R. G. Nelson GEOPHYSICIST	Drn. R.G.N.	SCALE: 1:10 000
		Tcd. A.F.	76—199
		Ckd.	
Director of Mines		Exd.	DATE: 16-3-76