DEPARTMENT OF MINES
SOUTH AUSTRALIA

BARABBA GRAVITY SURVEY
STUDENT PROJECT

by

P. Williams
Student

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INTRODUCTION

A gravity survey was carried out in the Mallala-Balaklava area located about 56 km north of Adelaide as shown on Fig. 1.

Twelve days were spent in fieldwork. Reduction and interpretation of results occupied a further fourteen days.

The aims of the survey were threefold.

(1) To investigate the possibility of sufficient sedimentary section being present in the vicinity of the supposed Redbanks Fault to provide a structural situation favourable to the retention of injected natural gas. This would provide a sub-surface storage along the route of the Cooper Basin pipeline and relatively close to the Adelaide market.

(2) To determine the thickness of sedimentary section and investigate the possible existence of aquifers suitable for development either for stock or market garden usage.

(3) To investigate the possibility that a connection existed during Tertiary time between the area of coal deposition at Inkerman-Balaklava and the area under investigation. If such a connection could be inferred from the geophysical data it would be necessary to extend any projected drilling programme.

The gravity work carried out was therefore the initial phase of an exploration programme involving refraction and reflection seismic profiling, relatively deep drilling to test groundwater/gas storage possibilities, and possible shallow drilling if a coal prospect should emerge.

Results are presented as contours of Bouguer anomaly together with a series of cross-sections derived by computer processing of the gravity data.

GEOLOGY

The St. Vincent Basin is a fault controlled graben with Tertiary sediments resting upon rocks of Permian or greater age (Parkin et al., 1969).

The western margin of the basin is associated with the southern extension of the Torrens Fault Zone, whilst the easterly margin is characterised by a series of northeast-southwest trending faults (Fig. 2). Movements along these faults have contributed to the formation of three so-called sub-basins named Willunga Sub-basin, Noarlunga Sub-basin, and the Adelaide Plains Sub-basin. The area under discussion is located in the last of these.

The tectonic history of the St. Vincent Gulf Region is complex and has been discussed at some length by Stuart and Von Sanden (1972). The geological significance of the area under investigation, however, is related primarily to the history of the Redbanks fault, a prominent feature extending from the mid-gulf area to the vicinity of Owen township, a distance of about 70 km. It is claimed (Stuart and Von Sanden, 1972) that the likely southern extension cuts through a fault zone present during late Precambrian time, rejuvenation occurring during the final phases of intra-Cambrian and Middle Cambrian-Permian.

Renewed movement in the area occurred during the Eocene (Parkin et al.,1969) associated with the deposition of the early Tertiary sediments.

In the Inkerman-Balaklava area it is considered (Meyer, 1976) that deposition of the coal is controlled by differential movement of fault blocks. Although in the area under investigation the Redbanks fault exhibits a prominent scarp, this becomes less evident to the north and the northern limits of the presumed fault are uncertain.

No deep bores have been constructed near the area of the survey. Extensive drilling has taken place, however, both to north and south. The stratigraphic succession is locally therefore somewhat uncertain but a generalised stratigraphic column for the Northern St. Vincent Basin is shown as Fig. 3. A geological map is shown as figure 4.

PREVIOUS GEOPHYSICS

The area lies upon ADELAIDE 1:250 000 map sheet which has been the subject of a number of gravity surveys. Coverage is variable but in general consists of readings on a four mile grid basis with readings at closer intervals over areas of special interest. Among these more detailed surveys are those of Kerr-Grant (1951) in the Inkerman-Balaklava area, groundwater investigations on the North Adelaide Plains and Barossa Valley and earlier work by J. McG. Hall in the Mallala area.

All these data have been integrated and plotted on the ADELAIDE gravity sheet as yet unpublished.

A reflection seismic survey was carried out in the Port Gawler-Lower Light area (Seedsman, 1964). The only seismic work in the area of the Redbanks Fault is a single east-west refraction seismic traverse carried out by S.A.D.M. during 1976. (Fig. 5).

Resistivity data is also available along this traverse.

The results from these two surveys have been used in the interpretation and will be discussed in that part of the report.

The area has been covered by aeromagnetic surveys but these data have not been used in this report.

FIELD METHODS

Gravity stations were established on a sub-regular grid (figure 6) with a spacing of about 2 km. Stations were located on roads and identified on aerial photographs. Gravity ties were made to stations established on previous surveys to enable the new data to be integrated into the ADELAIDE gravity sheet.

The gravity meter used was a Sharpe 190G. The calibration factor derived prior to the survey was 0.1000815 mgals/scale division determined on a standard calibration run from Kensington Gardens to the Norton Summit Station. An instrument malfunction during the course of the survey necessitated a further calibration survey and the factor used subsequently was 0.10001796 mgals/scale division.

Elevations of stations were obtained by barometric levelling. In this case mobile and base barometers were used with ties being made to established bench marks wherever possible. During the course of survey it was evident that some inaccuracies could be caused by high ambient temperatures. Care was teken to minimise these effects by repeated readings and positioning of the instruments in the shade.

Field procedures consisted of identifying on the ground, locations previously selected, as part of a complete loop which would consist of about eight stations and would be completed in about 70 minutes. If repetition of the base station showed instrument drift to be greater than 1.5 scale divisions the loop was repeated.

At each station the location number, gravity reading, barometer reading, and time were recorded, along with a sketch of the position of the station (figure 7).

REDUCTION OF RESULTS

a) Elevation

An abbreviated network diagram was constructed (Fig.8). This consisted of base stations, tie stations, and control points. The control points were selected so that they formed part of a loop with a "fixed side". The eight control points were either stations established on previous gravity surveys or were survey benchmarks.

Closure errors were calculated for individual networks and the total error minimised by a least squares graphic adjustment. This procedure is described in some detail by Smith (1951) but consists essentially of ensuring that:

1) the algebraic sum of the corrected differences around any circuit is zero
2) the sum of the weighted corrections at any junction is zero.

Thus it can be seen that if the errors in the abbreviated network are minimised, then each individual station can be related, through the base station, and hence a complete low error grid is derived.

Probable maximum error in elevation is estimated to be 10 feet.

b) Gravity

On the basis of repeat readings, drift curves were plotted for each loop, and corrections applied to compensate for instrument drift. Gravity interval values were calculated and hence an observed gravity value for each station. An abbreviated network was then constructed, similar to that used for the elevation data and by the least squares procedure any errors are minimised. It is then possible to derive an observed gravity value for each individual station on the grid.

Corrections must then be applied for latitude and elevation effects.

i) Latitude

This accounts for the increase in gravity from equator to pole. Latitudes and longitudes of stations were derived from a digitizer. Four points of known latitude and longitude within the local area are used and interpolations are made for each station. They are considered to be accurate to four significant figures.

ii) Elevation

A combined Free-air and Bouguer correction was applied to account for the decrease of gravity with increase of elevation and the attraction of material between the base elevation and that of individual stations.

The computations were carried out using a Wang computer and values of Bouguer anomaly derived for a range of densities from 1.9 gms/cc to 2.7 gms/cc at intervals of 0.1 gms/cc.

Bouguer gravity values were then obtained for a density of 2.67 mgs/cc by modification of the values obtained for 2.7 gms/cc.

These values were then plotted on a scale of 1:125,000 and integrated with existing data. The data were contoured (fig. 9) and profiles derived from these contours. (Fig.5).

INTERPRETATION

At the inception of the investigation the gravity programme was designed to locate accurately the Redbanks fault and to provide an estimate of possible throw. Then, if a reasonable thickness of sediments could be presumed on the downthrown side a drill hole would be constructed to test for the presence of reservoir and seal.

Interpretation of the early data by J. McG. Hall (Pers Com) involved computer modelling and it became evident that the field gravity curve would not fit a model involving a single normal fault. It was possible, however, to obtain a match using a fault zone with a series of faults downthrown to the west. It also seemed likely that the depth of sediments was somewhat greater than expected. A more detailed programme of geophysics was therefore considered desirable prior to selection of a drill site.

A single resistivity traverse partially confirmed the hypothesis that no clear cut fault existed and an east-west seismic refraction traverse was also carried out. The results of this traverse are presented as Fig. 5. It can be seen that no evidence exists to justify a fault in the presumed location. The profile would appear to resemble that derived from erosional processes. This does not preclude the possibility that a fault exists in the older Cambrian or Pre-Cambrian basement material underlying the Tertiary at this stage, however, there must be a strong presumption that it was not active during Tertiary time. It is stated in Parkin (1969) that the three sub-basins of the St. Vincent Basin are characterised by a gentle southerly dip towards the faults defining their southern margins. This would seem to support the hypothesis of decreasing rejuvenation of the Redbanks Fault to the north.

It is clear that for a potential hydrocarbon storage trap to exist several criteria must be satisfied. Unless recourse is made to largely stratigraphic trapping mechanisms there must be seal against the erosional slope to the east, and probable dip closure in three other directions. It would seem that these criteria are more likely to be achieved by tectonic movements in Tertiary times than during the infilling of an erosional depression.

To test this theory using the gravity data, computer modelling using a step type model was carried out. Initially a gravity profile was constructed along the refraction seismic profile and attempts were made to construct a theoretical curve to match this field curve. Using a constant density contract of 0.8 gms/cc between basement and sedimentary infill did not produce a satisfactory fit (Fig.5). The model was modified by changing the density contrast to 1.0 gms/cc on the western part of the traverse and to 0.72 gms/cc near the easterly end. A good fit was then obtained between theoretical and field curves. Thus there is the implication that a marked change occurs in basement density along the traverse. The only other control to basement depth in the area is a single seismic spread north of the refraction traverse. An east-west gravity profile was constructed through this point and by a similar computer modelling programme a basement profile was derived. Again a change of basement density along the profile was designed into the model. A north-south profile linking the two east-west profiles was also modelled.

It can be seen from the results that the gravity data is consistent with a change in basement density to the west. It follows therefore that the usefulness of the gravity technique as a mapping tool suffers from severe limitations in this area.

It is clear that similar problems exist to the north in the Inkerman-Balaklave region. Here the gravity is distinguished by strong regional effects which are clearly reflecting deep seated intra Cambrian or Pre-Cambrian features rather than the thickness of Tertiary sediments.

Thus, the concept of a differing tectonic history for the area under study is reinforced. It is necessary to consider whether the presumed change to the west is associated with the original ?Redbanks fault and the present surface indication is merely the result of scarp retreat or whether the minor density change at the eastern extremity does represent faulting in the older rocks.

On the information now available a definitive interpretation is not possible. It is clear, however, that if the gravity method is to be useful in predicting the thickness of the Tertiary sediments, then tight control is required either by drilling or carrying out further seismic surveying. Even with this control it would seem desirable that any future gravity stations would require close spacing and accurate elevation control. Only under these conditions would it be feasible to separate near surface effects from the strong regional gradients.

With regard to deposition of coals the survey has not been definitive. It has shown that the tectonic style differs from the known deposits to the north which appear to be controlled by a later phase of faulting than is present in the area of investigation. Although the existence of conditions favourable to coal deposition cannot totally be discounted it does not seem likely that this area represents a simple extension of the Inkerman-Balaklave deposits.

A simple calculation, however, shows that if an overburden to seam ratio of 10:1 is taken for a seam 10 m in thickness then a coal body of up to 2,000 million tonnes could be present in this depression. It is evident that this possibility along justifies a drill hole to determine the Tertiary stratigraphy.

7 With respect to underground waters the position is perhaps a little more optimistic. It would appear likely that some aquifers should exist and that the possibility of re-charge from the alluvial slope must be considered. In this case water could be better than would normally be the case in this area. This matter must again be resolved by drilling.

In addition to the above major economic possibilities the likely occurrence of materials for the construction and allied industries must be considered. These would include building sand, flint, clay etc.

CONCLUSIONS

The results of the gravity surveys were somewhat inconclusive. It is considered essential that a bore be drilled to establish the Tertiary stratigraphy.

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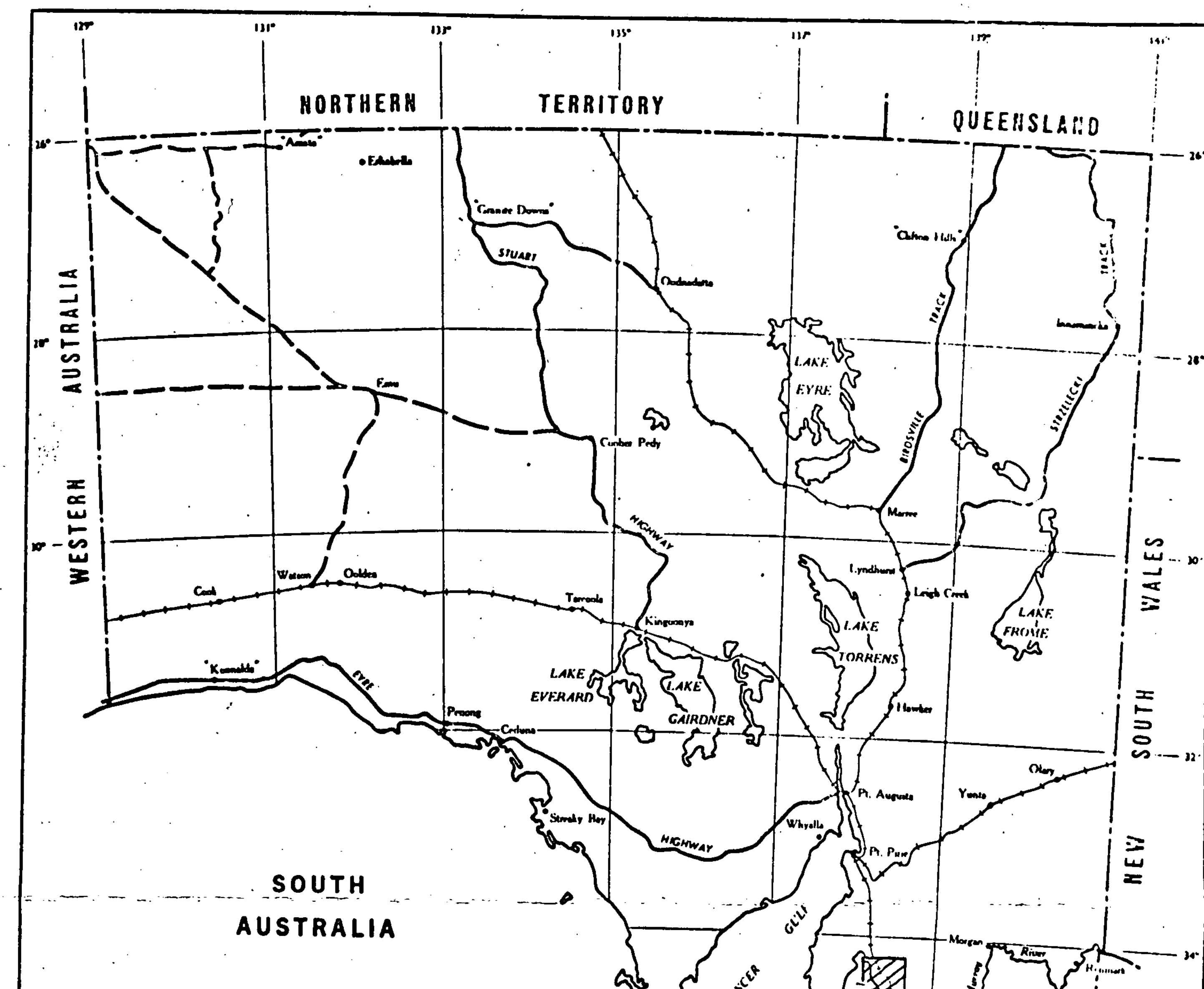
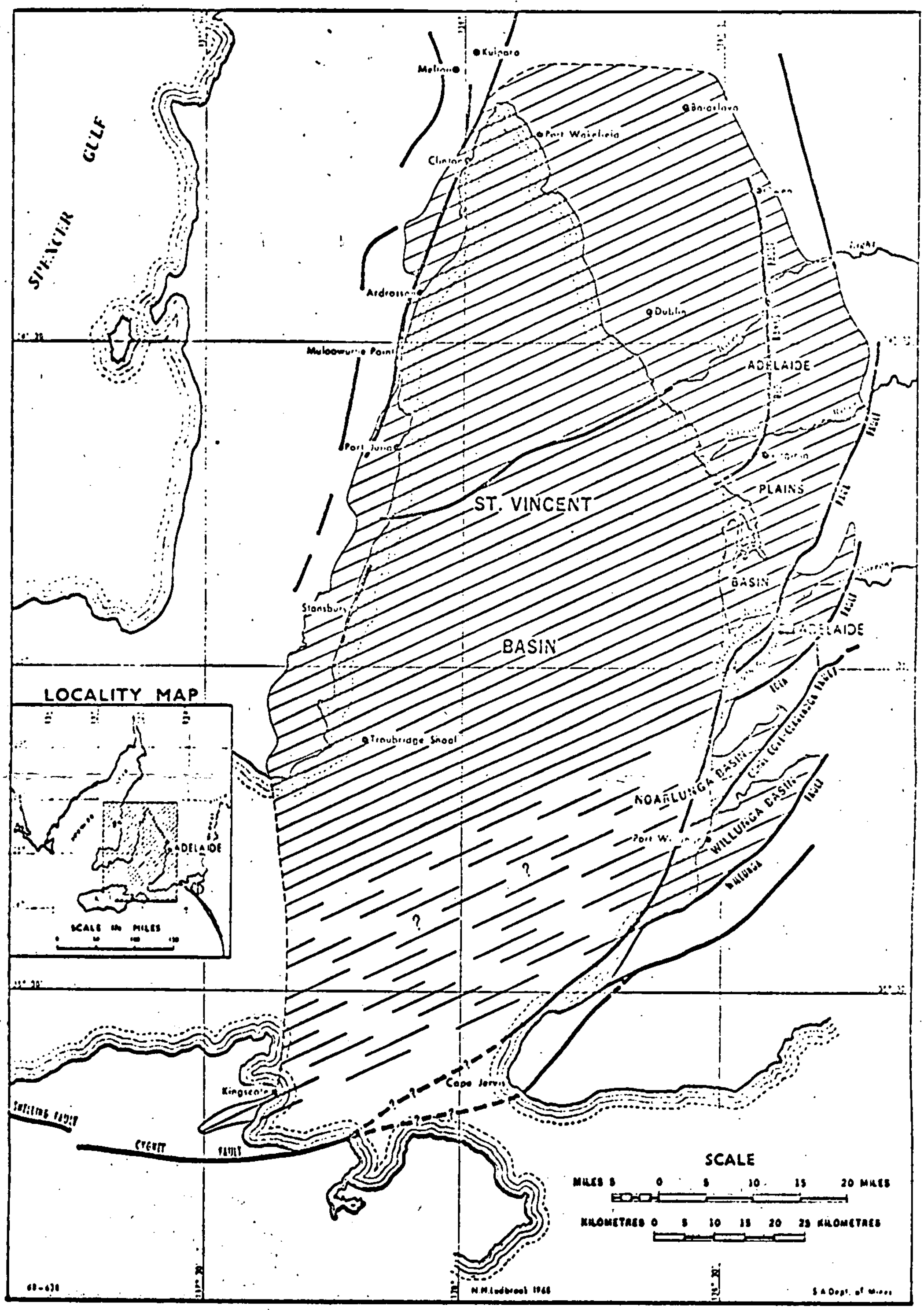


DEPARTMENT OF MINES —— SOUTH AUSTRALIA

Compiled.		BARABBA GRAVITY SURVEY	Date:
Drn.	Chd.	LOCALITY MAP	Drg. No.

P.F. No 55850 994.2

Figure 1



	DEPARTMENT OF MINES–SOUTH AUSTRALIA	Scale:
Compiled:	**BARABBA GRAVITY SURVEY**	Date:
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500 – 11.76 H1081 O

Figure 2

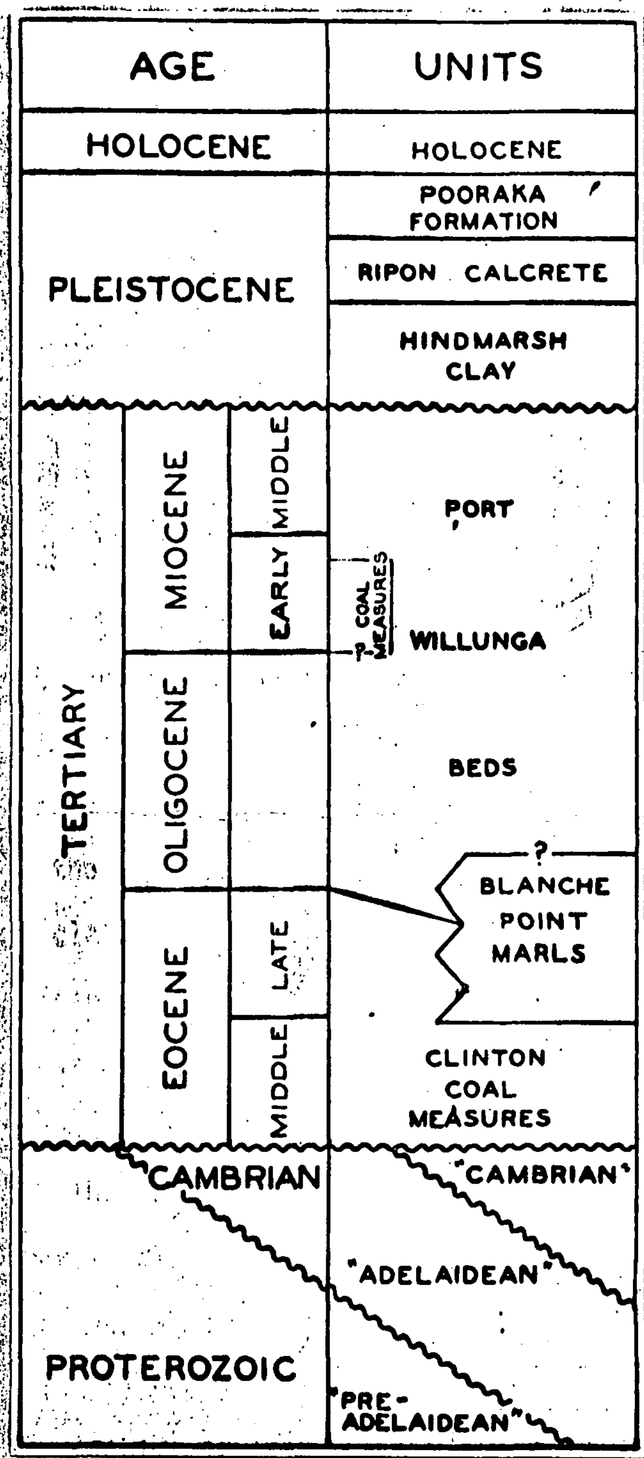

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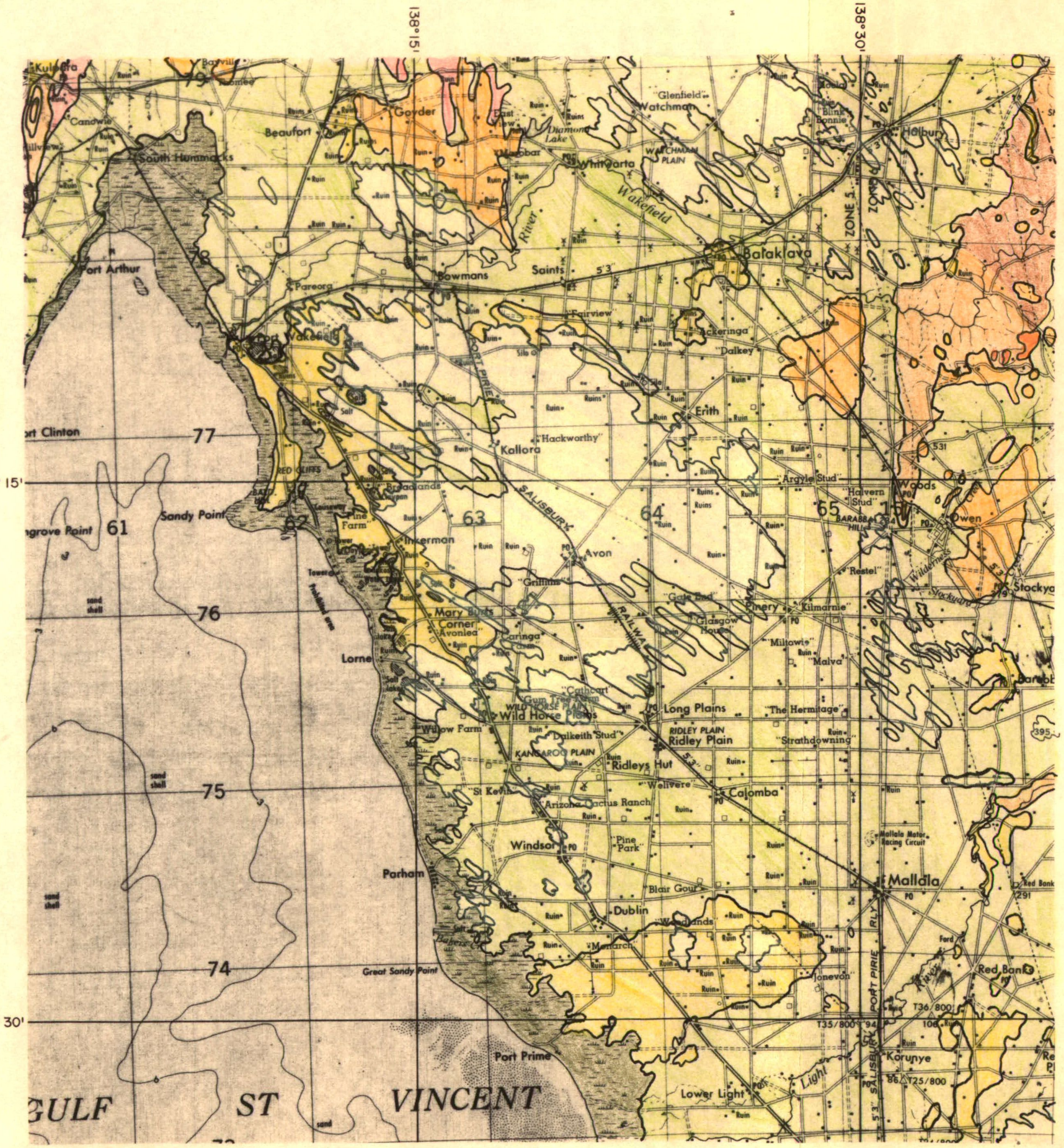
Figure 3



REFERENCE

CAINOZOIC — QUATERNARY — RECENT

- Grey fluviatile silts, sands and gravels of the modern drainage channels.
- Red brown aeolian FULHAM SAND and pale yellow MOLINEAUX SAND of the dunefields, underlain in places by Pleistocene aeolian calcareous sand of the WOORINEN FORMATION.
- ST. KILDA FORMATION: Light grey shelly stranded beach ridge deposits and shelly silts and sands overlain in places by modern intertidal and swamp deposits.

PLEISTOCENE

- POORAKA FORMATION: Pale red-brown sandy clay containing carbonate of the LOVEDAY SOIL.
- Calcrete in BAKARA SOIL with RIPON CALCRETE at base, nodular and platy carbonate.

TERTIARY

- Laterite, ferrigunous residual.
- Undifferentiated white quartz sand and pebbly conglomerate, sandy clays, in places with ferrigunous matrix (contains NORTH and SOUTH MASLIN SANDS and CLINTON COAL MEASURES).

PROTEROZOIC — ADELAIDE SYSTEM

WILLOURAN — RIVER WAKEFIELD GROUP

- BLYTH DOLOMITE BEDS: Grey and black dolomite.
- Unnamed sandstone, phyllite and dolomite.

MARINOAN

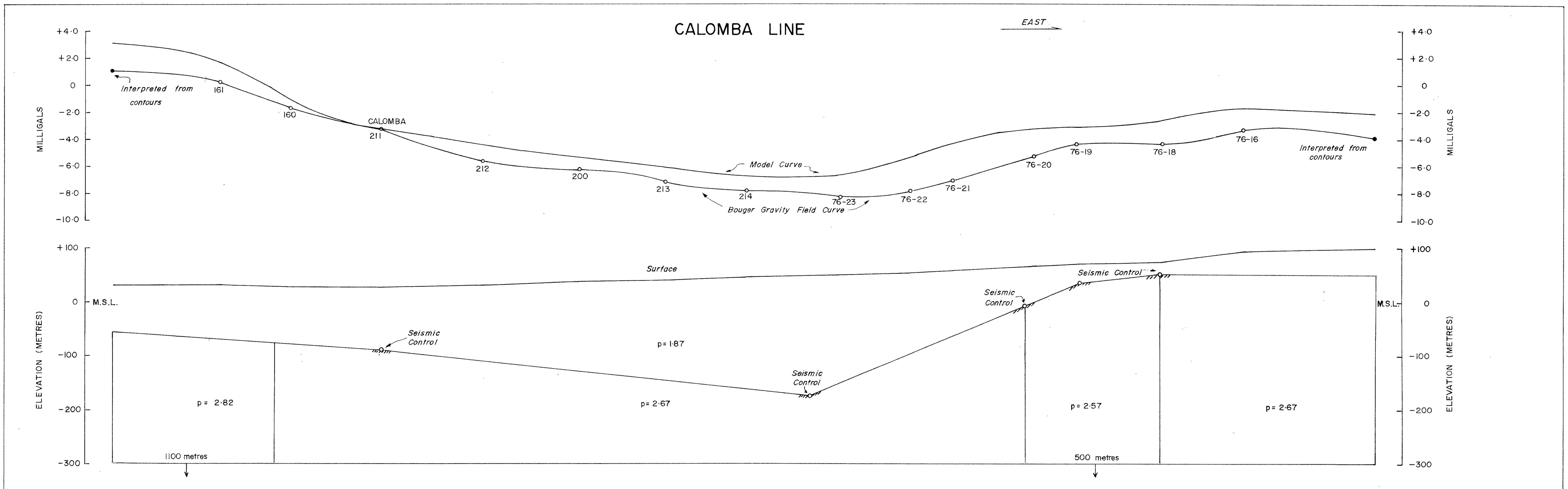
- TENT HILL FORMATION: White quartzite and red-purple sandstone.

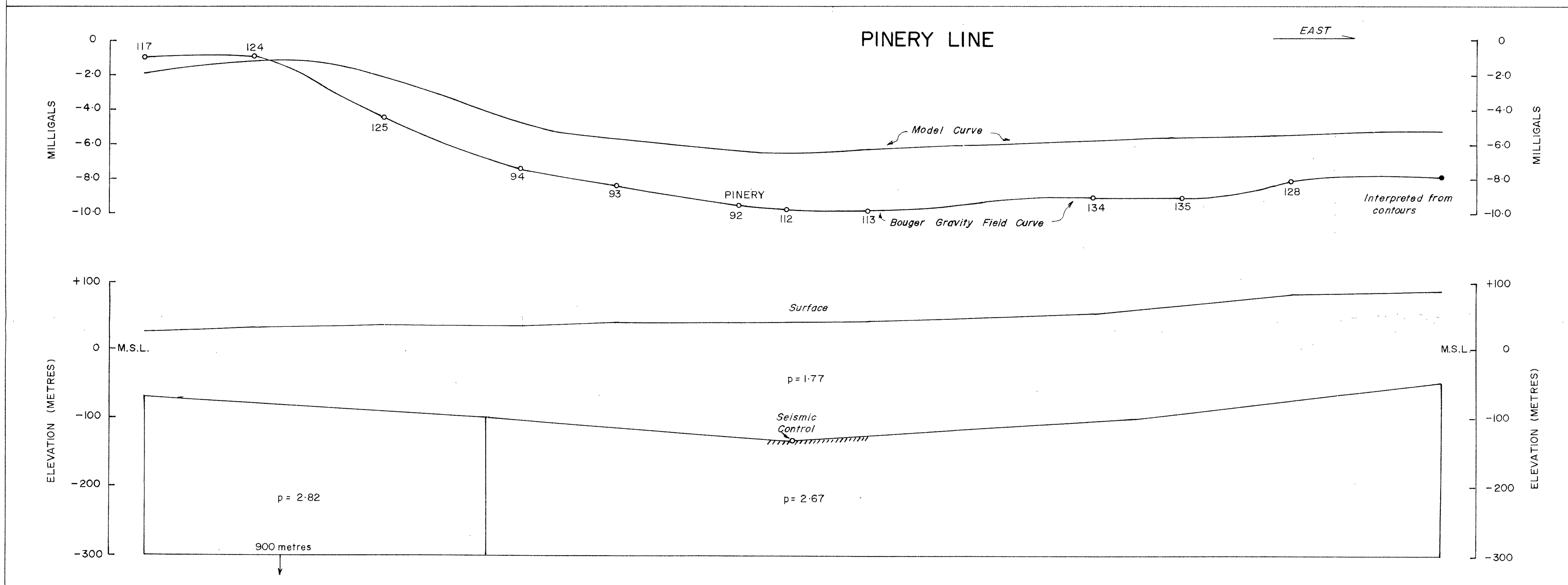
SCALE 1:250,000

KILOMETRES 5 0 5 10 15 20 25 KILOMETRES

DEPARTMENT OF MINES – SOUTH AUSTRALIA		SCALE. 1:250 000
COMPILED: P. Williams	**MALLALA – BALAKLAVA GRAVITY SURVEY**	DATE: 25·1·77
DRN: / CKD.	GEOLOGICAL MAP OF THE NORTHERN ST. VINCENT BASIN (AFTER ADELAIDE 1:250,000)	PLAN NUMBER:

Figure 4



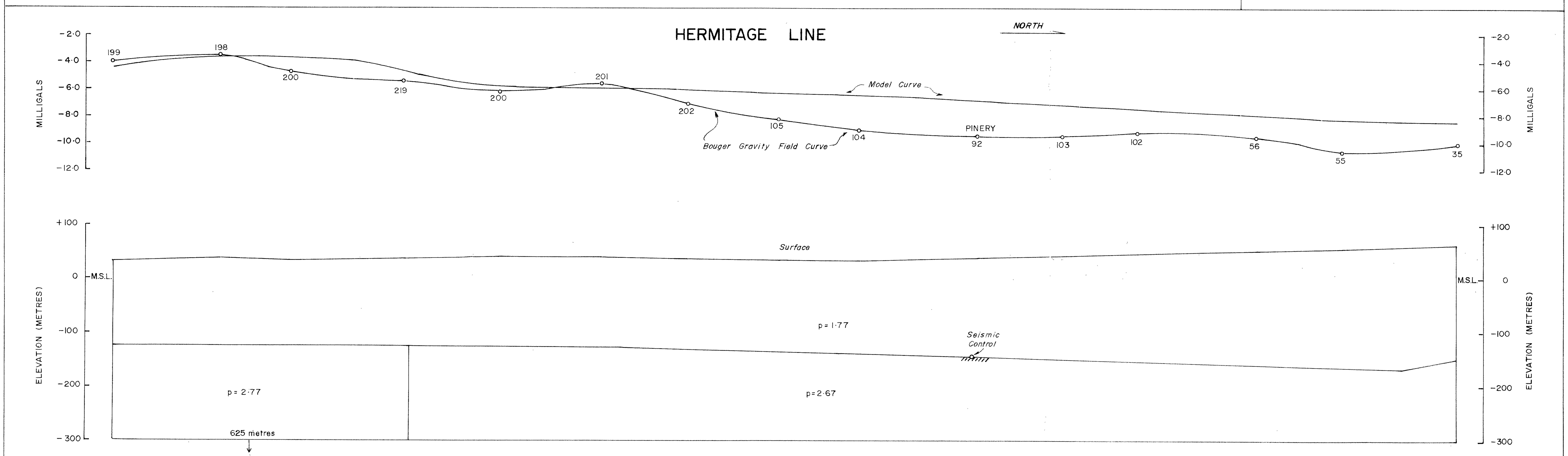


REFERENCE

Quaternary – Tertiary sands, silts and clays.

Adelaidean ? or Cambrian dolomites, phyllites and sandstones.

p = 2·67 Assumed density for computer modelling.

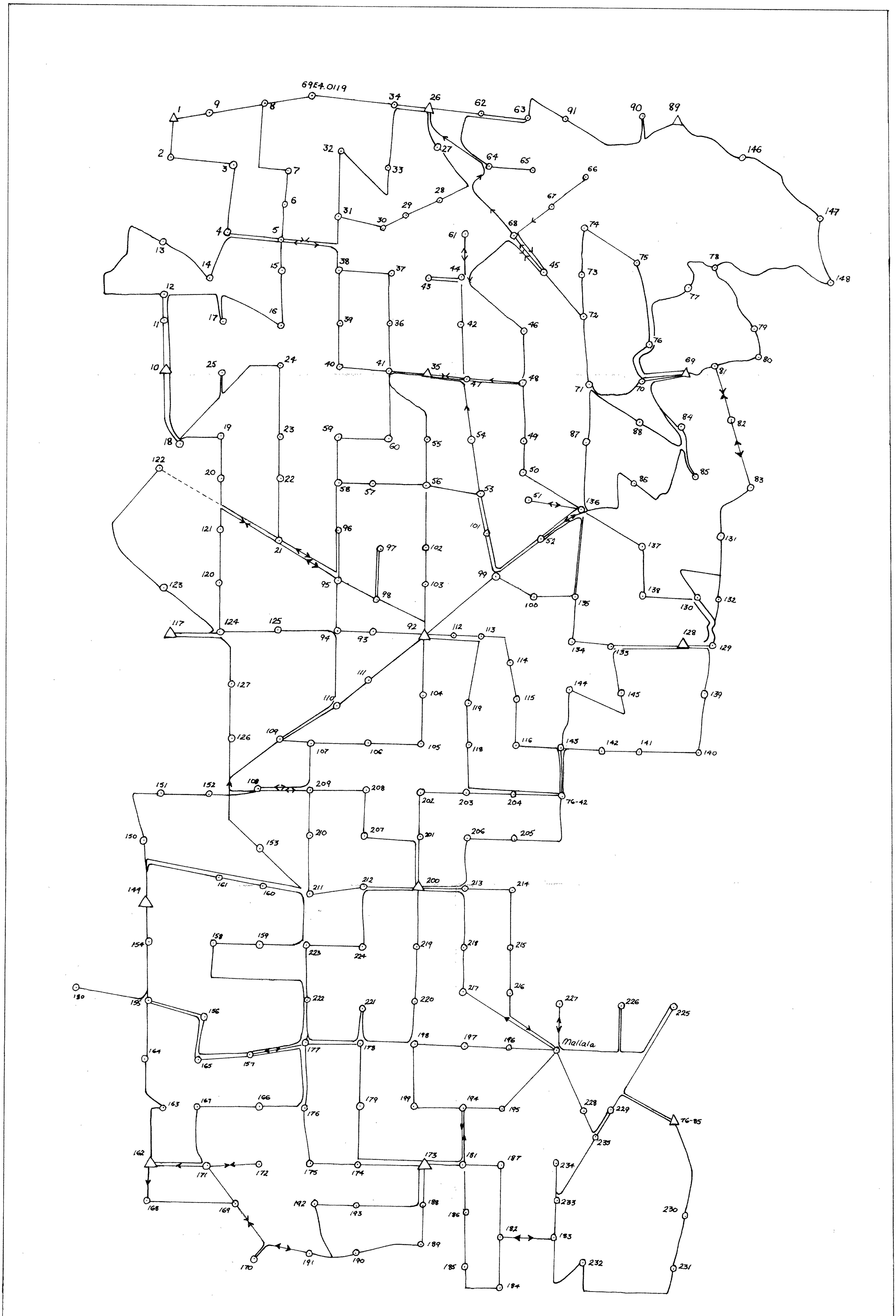


DEPARTMENT OF MINES–SOUTH AUSTRALIA

BARABBA GRAVITY LOW
COMPUTER MODELLING PROFILES

	COMPILED:	DRN:	SCALE: 1:50,000	PLAN NUMBER
DIRECTOR OF MINES		CKD:	DATE: Jan 28 '77.	

Figure 5



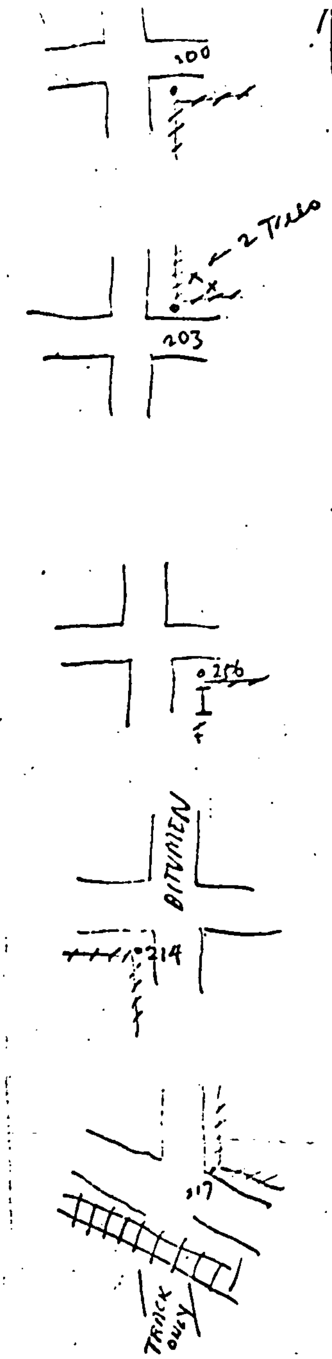
SUB-REGULAR GRID OF GRAVITY STATIONS

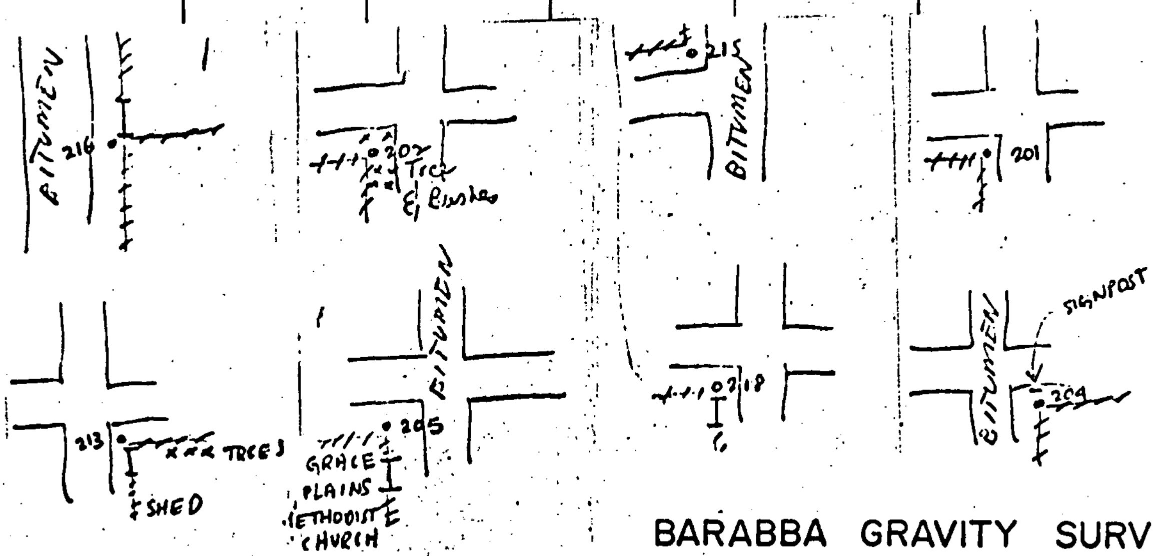
BARABBA GRAVITY SURVEY

Figure 6

Traverse 1 Date 13/12/76

Station	Time	Reading	Drift Correction	Corrected for Drift	Rel to Prev. Value
200	1151	678.4	–	678.40	–
201	1159	670.35	-0.06	670.29	-8.11
202	1205	651.05	-0.10	650.95	-19.34
203	1211	632.3	-0.14	632.16	-18.79
204	1216½	622.6	-0.18	622.42	-9.74
76-42	1221	618.0	-0.21	617.79	-4.63
205	1229	632.05	-0.27	631.78	+13.99
206	1234	650.35	-0.30	650.05	+18.27
200	1241	678.75	-0.35	678.40	+28.35
76-80	1319	695.9	–	695.90	–
216	1326	690.7	+0.6	691.30	-4.60
215	1332½	670.3	+0.12	670.42	-20.88
214	1340	648.35	+0.18	648.53	-21.89
213	1346	662.5	+0.24	662.74	+14.21
200	1352½	678.1	+0.30	678.40	+15.66
218	1400	685.6	+0.36	685.96	+7.56
217	1405	704.6	+0.41	705.01	+19.05
76-80	1412½	695.45	+0.45	695.90	-10.89

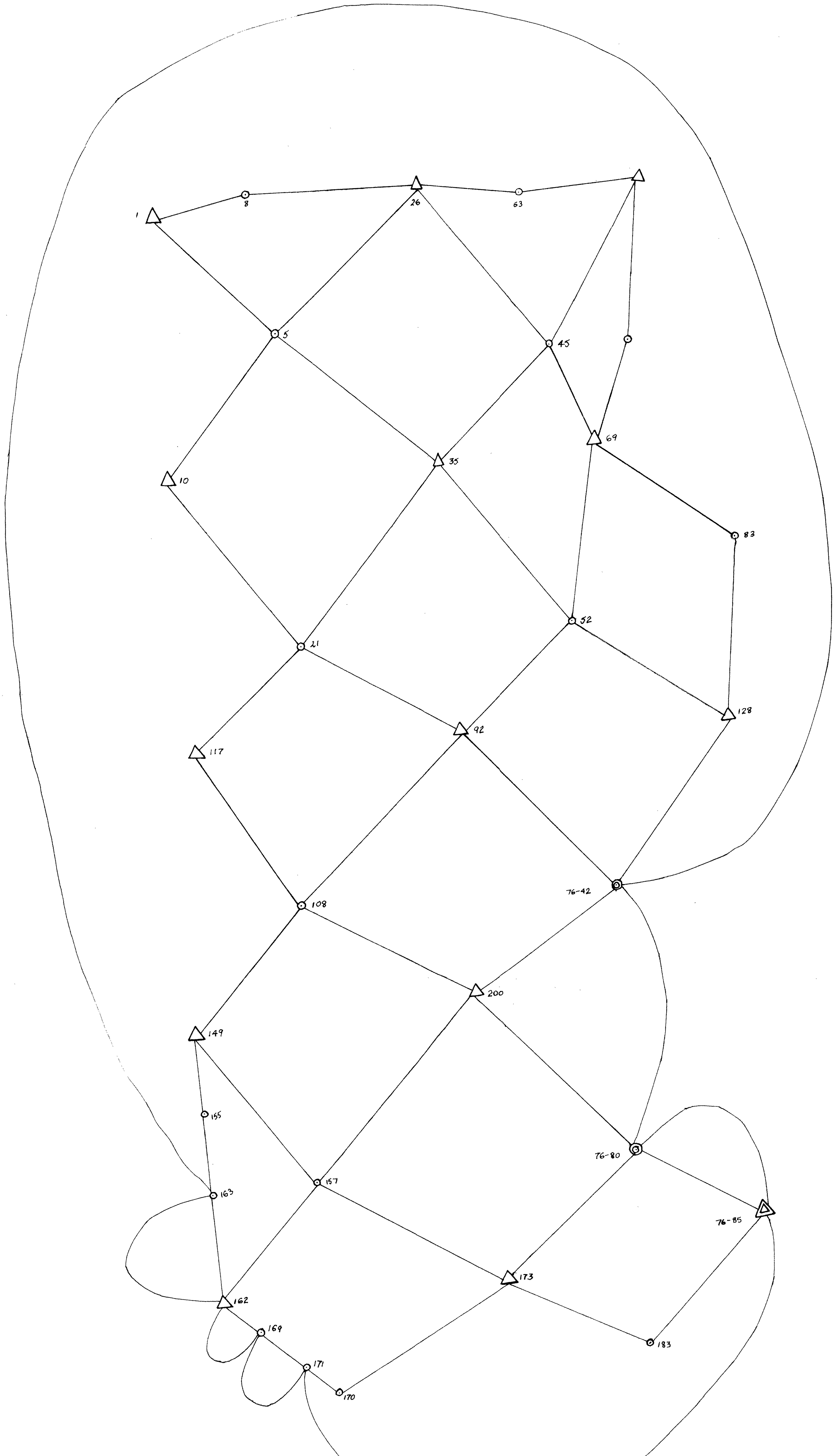




BARABBA GRAVITY SURVEY

SAMPLE PAGE - FIELD BOOK

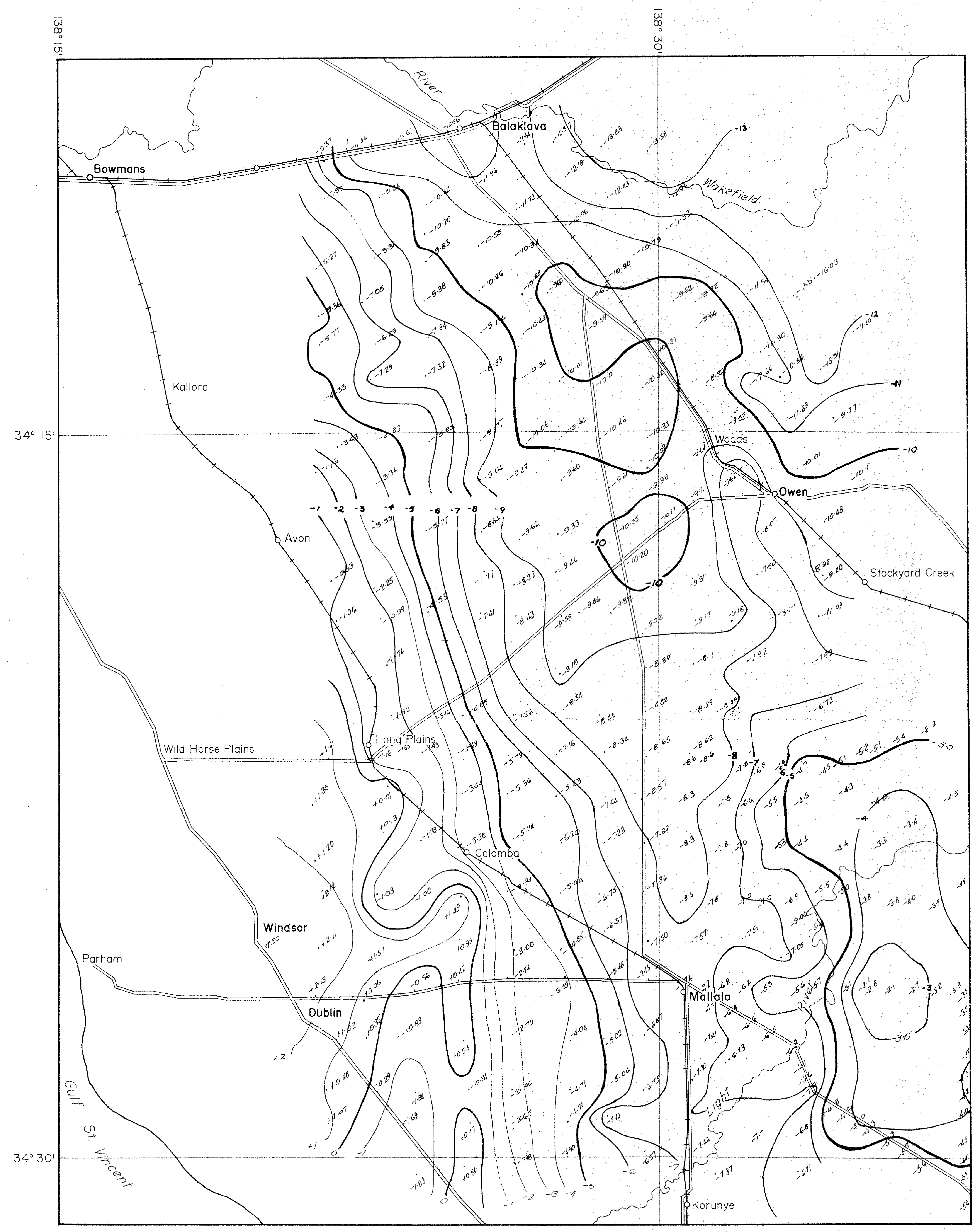
Figure 7



ABBREVIATED GRAVITY NETWORK DIAGRAM

BARABBA GRAVITY SURVEY

Figure 8



0 5 10km

DEPARTMENT OF MINES – SOUTH AUSTRALIA				
MALLALA – BALAKLAVA GRAVITY SURVEY				
FINAL INTEGRATED GRAVITY CONTOUR MAP				
	COMPILED: P. Williams	DRN:	SCALE: 1:125 000	PLAN NUMBER
DIRECTOR OF MINES		CKD:	DATE	

Figure 9