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GEOPHYSICAL SURVEY AT THE YITHAN ALLUVIAL TIN MINE, ARDLETHAN, N.S.W.

By

M. J. O'CONNOR

with an [redacted]

APPENDIX

by

J. Daly.

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ABSTRACT.

A geophysical survey was made over the Upper Yithan Alluvial Tin Mine in March of 1959. The area covered was an extension of an area surveyed by the seismic refraction method in 1956. Seismic refraction and gravity methods were used. Five traverses were surveyed with the seismic method. The gravity method was used on these five traverses as well as three other traverses of the 1956 survey.

The survey indicated that the main lead traced by the 1956 survey changes direction in the northern part of the area and rises sharply as it approaches the outcropping granite. The site of a new shaft to be sunk to the deep lead is recommended.

The gravity survey gave an anomaly corresponding with the position of the lead as deduced from the results of the seismic survey. The gravity method appears to be suitable for detecting and tracing deep leads of the type at Yithan.

1. INTRODUCTION.

The Yithan Alluvial Tin Mine is situated near the old village of Yithan, about 3 miles north-west of the township of Ardlethan, N.S.W., which is approximately 340 miles west of Sydney.

Tin was first discovered in the area in 1912 at the White Crystal Mine near Yithan. Alluvial tin was later found in a shallow lead on a false bottom between the Carpathia and Southern Cross hillsides. In 1951, a drilling programme by Mt. Isa Mines Pty. Ltd. to the north, south and east of the White Crystal leases revealed a tin bearing lead at a depth of 160 feet, approximately ¾-mile to the south-east of the White Crystal leases. Prospectors Pty. Ltd. began working the deep lead tin in 1953.

A seismic refraction survey was carried out by the Bureau of Mineral Resources in 1949 to locate possible deep leads in the alluvial area immediately to the east of the Bygoo Mines which are 4 to 5 miles north of Yithan (Urquhart, 1956). In 1956, when three shafts had been sunk to the deep lead at Yithan, a seismic refraction survey was carried out by the Bureau at the request of Prospectors Pty. Ltd. (O'Connor, 1958). The main part of this survey consisted of thirteen traverses from No.1 shaft to the north-west for a distance of approximately 3,500 feet. Two traverses were also surveyed to the south of No.1 shaft.

The geology and mineralisation of the Ardlethan area have been described by Godfrey (1915), Harper (1919) and Garretty (1953). A summary of the geology in the Yithan area has been given in the report on the 1956 geophysical survey. The alluvial tin is found in leads or stream channels on the weathered bedrock surface of granite or Palaeozoic sediments (mainly slates). The tin-bearing wash of the leads is generally about 60 feet wide and covered by 100 to 150 feet of alluvium (mainly red lateritic and sandy clay). The northern-most part of the lead discussed in this report however, borders areas where granite and Palaeozoic sediments crop out extensively.

This report describes the geophysical survey made by the Bureau of Mineral Resources over the extension, to the north-west of the area surveyed by the Bureau in 1956. The survey was requested by Prospectors Pty. Ltd. in order to trace the course of the lead further to the north-west with a view to selecting a suitable site for a new shaft.

The geophysical party consisted of two geophysicists M. O'Connor (party leader) and E. Sedmik (geophysicist), and three field assistants. Two additional field assistants were provided by Prospectors Pty. Ltd. The field work was done in March, 1959.

2. PREVIOUS GEOPHYSICAL SURVEYS.

The seismic refraction survey of 1955 encountered difficulties due to the presence of a zone of hard rock close to the surface, in which the velocity of seismic waves was about 5,000 feet per second. The shot hole drill used by the party could not penetrate this zone, so that the velocity in the underlying clays could not be measured by the usual methods. Shots were therefore fired in two old shafts sunk on the lead, and the average vertical velocity in the overburden between bedrock and ground surface was determined as 3,100 feet per second. This has been used as the velocity of the overburden in reducing the results.

The results indicated the probable course of the lead, and also the presence of a basin shaped depression in the bedrock along the lead. Two shafts were sunk on the basis of this work. Shaft No.4 intersected the lead as predicted, and was used for mining up to its economic limit. Shaft No.5 was sited close to the depression mentioned above. It also intersected the lead in the predicted position, but was not used for mining for the following reasons -

(1) The tin content of the lead where intersected was found to be too low for profitable mining. However, a drive along the lead upstream (towards the depression) indicated that values were improving in this direction.

(2) The ground was very bad.

The cause of this depression is not certain. However, the results from shaft No.5 suggest that it is probably due to a zone of abnormally deep weathering in the bedrock.

The present survey was intended to trace the course of the lead north of this depression, where mining conditions and tin values could be expected to improve.

3. APPLICABILITY AND DESCRIPTION OF METHODS.

The gravity method was used on this survey mainly as a trial to find out if this geophysical method could be successfully applied to the detection of deep leads. Gravity surveys as a means of tracing deep leads depend on the contrast in densities of the overburden and the bedrock. As the clays and sands are less dense than the bedrock the position of the lead should be indicated by a gravity low.

The gravity method can be used to cover a large area in a relatively short time. Its main use in deep lead prospecting would be the survey of large areas at reconnaissance scale with a view to selecting smaller areas for seismic surveys which can give more detail than gravity surveys.

4. FIELD WORK AND RESULTS.

(A) SEISMIC.

Twelve normal spreads, with geophone spacings of 50 feet and seven weathering spreads, with geophone spacings of 10 and 20 feet were shot. The total length of traverses surveyed was 4,500 feet.

The equipment used was a Century 12-trace seismograph. The shot holes were bored with a Proline drilling equipment mounted on a Land Rover and driven from a power take-off. For normal spreads, shots were fired from 50 feet and about 400 feet from each end of the spreads. The shots at 50 feet from the spreads were mainly used to investigate any changes in the overburden and the average charge was 1 lb. of AN60 gelignite at an average depth of 6 feet. The distant shots were used to record refractions from the bedrock as first arrivals and the average charge was about 2½ lbs. of gelignite at an average depth of 9 feet. The weathering spreads were designed to obtain detailed information about the velocities in the near surface layers. Shot points for these spreads were put at 10 feet from each end of the spread and the charges were generally ¼ lb. gelignite at a depth of about 3 feet.

The depths to unweathered bedrock were computed by the "Method of Differences" as described by O'Connor (1958) . The profiles of the unweathered bedrock as computed from the seismic results are shown in Plate 2. Plate 4 is a contour map of the surface of the unweathered bedrock, drawn from the profiles of Plate 2 and also from the profiles along traverses F, K, L & H of the 1956 survey.

(B) GRAVITY.

The gravity survey was done with Atlas Gravimeter No. F2. Measurements were made generally at 50 feet intervals along the traverses.

The gravity results are shown as Bouguer profiles on Plate 3 and as Bouguer contours on Plate 4. Two separate Bouguer reductions were made, one assuming a density of 2.0, which is considered to be applicable to the overburden, and one using a density of 2.65, which is an average value of the density of the country rock, as determined from tests on several samples. Contour plans were drawn for both densities (2.0 and 2.65) but they show only slight differences mainly because the topography is rather flat.

5. DISCUSSION OF RESULTS.

(A) SEISMIC.

The profiles of the present surface and unweathered bedrock in Plate 2 show that the depression in the bedrock is most marked on traverse R, where the lead is indicated to be about at 825. The profiles along S and T are flatter, and if such details can be relied upon there appears to be a splitting of the lead on traverses S, T and Z. However, the contour map of the unweathered bedrock on Plate 4 gives a better indication of the positions of possible deep leads in the northern area. The main features of the contour map are:-

(i) The main lead which was traced by the geophysical survey in 1956, and confirmed by the work in shaft No.5, appears to be traceable up to traverse T.

(ii) It seems possible from the seismic work that another lead joins the main lead between traverses S and T.

(iii) There is some evidence on traverse Z that the lead branches into two parts between traverses R and S. There are other possibilities to explain the two depressions on traverse Z. The depression centred at Z425 could also be due to a lead coming from the west and not intersected by traverse R or S. Either of the depressions along traverse Z could also be due to a local feature in overburden or bedrock and not associated with a deep lead. While the main trend of the seismic results is clear, it is not so certain that such details as changes in elevation of a very few feet can be relied on.

(iv) It should be understood that the position of the lead is only inferred from the bedrock contours. As the depth to bedrock can only be determined with a limited accuracy an error of a few feet could easily change the apparent position of the lead especially over relatively flat sections. Furthermore, it should be remembered that the bedrock profile is that of unweathered bedrock which will not conform in all details with the surface topography at the time the lead was formed. The results apply only to actual traverses, and the joining up of indications from traverse to traverse involves an element of conjecture.

(v) The depressions along traverse U centred at 400 and 750 may be significant but additional traverses parallel to U would need to be surveyed to enable any reliance to be placed on them.

(vi) The northernmost part of the basin-like structure, indicated by the results on the previously surveyed traverses L, K and F, is near traverse R. The level of the lead appears to rise rapidly between R and S and this rapid rise continues further upstream to traverse T.

The seismic velocities in the bedrock calculated from the time-distance curves drawn from the seismic records have been shown on the profiles of Plate 2. The values shown are measurements of the average velocity over several hundreds of feet of traverse. In areas where the geology is sufficiently simple, these velocities are often sufficiently diagnostic of rock types to enable the positions of contacts to be inferred. However, the results obtained in the present survey are not consistent with any simple geological pattern, and it is considered that no reliable inferences of this nature can be made from them.

(B) GRAVITY

The results of the gravity survey over the Upper Yithan Mine area are shown as profiles in Plate 2B and contours in Plate 5. Assuming that the lead is indicated by a minimum in the gravity values, the position of the lead as indicated by the gravity contours coincides remarkably well with the position of the lead as indicated by seismic results. Both the gravity and the seismic contour maps show a very similar picture. However, there are some differences in detail between the two maps. For instance, on traverse T the gravity results indicate a lead in approximately the same position as the western lead, as indicated by the seismic results. There is no clear gravity indication of a lead going through T475 but the gravity profile along T shows a point of inflection about T 450. On traverse S there is a displacement of about 50 feet between the gravity and seismic lows. On traverse R the gravity minimum is about 50 feet west of the seismic one. South of Traverse K both gravity and seismic results (the seismic work on these traverses was done in 1956), indicate a basin-like structure which broadens out on traverse L. On the seismic contour map, the lead has been shown passing through F 450, but there is no minimum in the gravity values near this point.

The gravity and the seismic methods utilise rather different properties of the rock formations and arrive at their results using quite different techniques of measuring and interpretation. It is therefore surprising that the results agree to such an extent. In particular, the basin-like depression between traverses F and K which has been found by both methods in nearly identical positions and with similar shape must be due to a significant geological feature in the bedrock. A possible explanation for this has been suggested earlier, Similar features have been observed in other areas, and it is a matter of great importance to the use of geophysical methods in prospecting for deep leads that the cause of such depressions be investigated by underground exploration.

6. CONCLUSIONS AND RECOMMENDATIONS.

The gravity and seismic contour plans are very similar in general form and the results suggest that the gravity method is suitable for detecting deep leads in the conditions that apply at Yithan; namely, a fairly flat surface topography and a considerable thickness of sands and clays overlying a well defined lead on granite or slate bedrock.

North of traverse R the unweathered bedrock rises quite sharply so that the deep lead would be expected to have a relatively steep gradient between traverses R and T. A recommendation is made for a shaft about R 825. This is regarded as the best site for a shaft because near this point the geophysical results suggest that the deep lead gradient changes from steep to flat, and that the lead changes course between traverse R and K. Thus, near the proposed shaft and to the south would be the most likely place for the concentration of tin values if the seismic results can be relied on to indicate the gradient of the lead.

There is not sufficient evidence from the geophysical surveys to infer any leads coming from the east or west in the area covered by the survey. However, the seismic results along traverse U suggest a slight possibility of leads from the east near U 400 and U 750. Additional seismic work on traverses parallel to U would be needed to prove whether or not there are tributary leads at these points.

7. REFERENCES.

GARRETTY, M.D., 1953 - The Ardlethan Tin Field, Geol. of Aust. Ore Deposits, Vol. 1.

GODFREY, J.R., 1951 - Report upon the Ardlethan Tin Field, Dept. Mines Geol. Surv. N.S.W., Mineral Resources 20.

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APPENDIX I.

NOTE ON THE POSSIBILITY OF USING GRAVITY METHODS TO ESTIMATE THE DEPTH TO THE BOTTOM OF A DEEP LEAD

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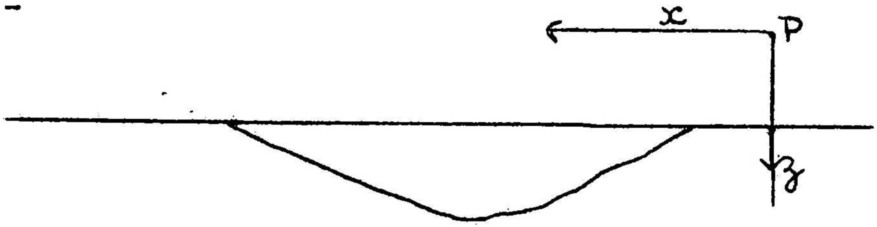
Suppose the lead consists of banks of solid rock at the same level with a gutter of lower density material between. A gravity profile at right angles to the course of the lead will give a negative anomaly. If results are reduced to the level of the banks the anomaly can be considered to be due to a gutter of negative density.

Suppose the section of the lead is as shown:-



Take rectangular axes, with X,& Z in the plane of the paper and Y along the lead.

Then, if the origin is at the measuring point, we have -

$$F = G.\rho.\iiint \frac{dx.dy.dz.z}{(x^2+y^2+z^2)^{\frac{3}{2}}}$$

taken over the lead. ρ is the density difference between the filling of the lead and the bedrock, and will be negative.

Integrate for y between $\pm\infty$

$$F = G.\rho.\iint dx.dz.z.\int_{-\infty}^{\infty} \frac{dy}{(x^2+y^2+z^2)^{3/2}}$$

$$= G.\rho.\iint \frac{dx.dz.z}{x^2+z^2}$$

taken over the section of the lead.

Change to polar coordinates centred at the measuring point.

Put x = R cos ϕ, z = R sin ϕ

$$\frac{\partial(xz)}{\partial(R\phi)} = R.$$

$$F = 2G\rho\iint \frac{dR.d\phi.R.R\sin\phi}{R^2}$$

$$= 2G\rho\iint dR.d\phi.\sin\phi$$

taken over the section of the lead.

If we integrate graphically, using a graticule consisting of circular arcs and radial lines we have -

$$F = 2G.\rho\sum_{R\phi}\int_{R_1}^{R_2} dR.\int_{\phi_1}^{\phi_2}\sin\phi\, d\phi$$

$$= 2G\rho\sum_{R\phi}(R_2 - R_1)(\cos\phi_1 - \cos\phi_2)$$

The graticule will therefore consist of circular arcs with uniformly increasing radii and radial lines spaced at angles such that cos ϕ increases uniformly.

The use of the graticule to estimate the depth to the bottom of a lead will depend on assuming a shape and depth, calculating the maximum (negative) anomaly and comparing with the observed value. A value forthe density contrast will have to be assumed. It will also have to be assumed that the anomaly attains the maximum value when the measuring point is vertically above the deep part of the lead. This will only be exactly true if the sides of the gutter are symmetrical, but in any ordinary case, it should be accurate enough for the purpose. It will also be necessary to use the profile to estimate the width of the lead at the top. This again can only be done roughly, but a small error is not likely to be significant.

As an example to check the sensitivity of the method, consider traverse T. This has been reduced to an arbitrary datum somewhat lower than outcrop, but the discrepancy may not be serious. Suppose the edges of the banks of the gutter are at T900 and T-50, and that the point of maximum anomaly is at T300. Assume also that the section of the gutter is in the shape of a triangle, and take depths of 50, 100, 150 and 200 feet. The maximum anomaly is about 0.55 milligal. Draw these asumed sections at a scale of 100 feet to an inch, and count the divisions covered by each on the graticule when the centre of the graticule is placed at ground level, vertically over the deep point of the section.

The following totals are obtained:-

Depth	Divisions covered.
50	28.6
100	48.1
150	65.1
200	82.4

The graticule has been drawn with radii increasing by half inches and Cos $\emptyset$ increasing by 0.1. At a scale of 100 feet to theinch each division gives an anomaly -

$$\Delta F = 2 \times 6.66 \times 10^{-8} \times 50 \times 30.48 \times 0.1 \rho \text{ gal.}$$

$$= 2 \times 6.66 \times 10^{-8} \times 50 \times 30.48 \times 0.1 \times 10^{3} \rho \text{ milligal}$$

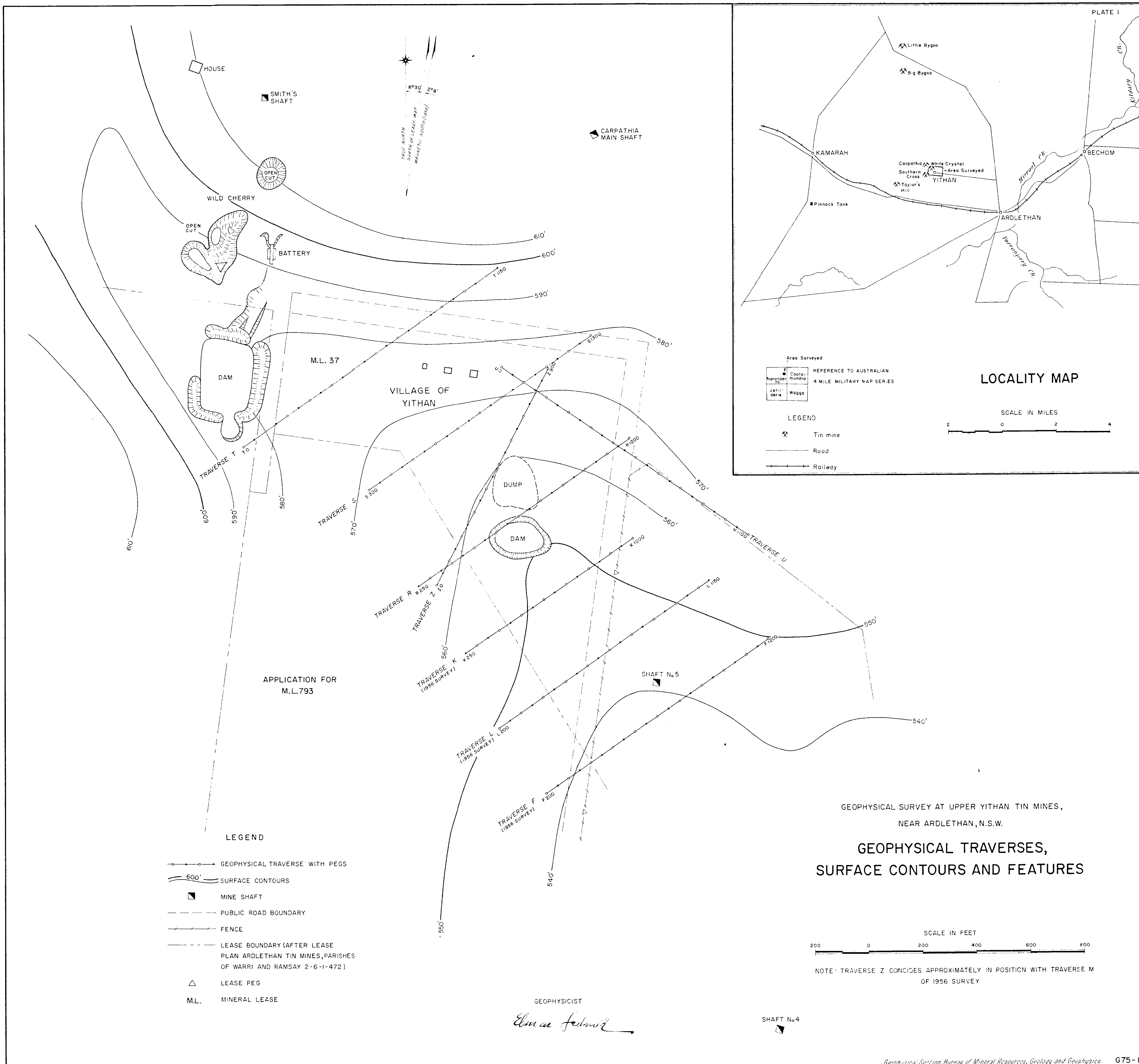
$$= 2.04 \times 10^{-2} \rho. \text{ milligal.}$$

For each depth given above we can therefore calculate the density contrast needed to make the anomaly equal to the measured value of - 0.55 milligal. We get -

Depth	Density Contrast required.
50	- 0.94
100	- 0.56
150	- 0.41
200	- 0.33

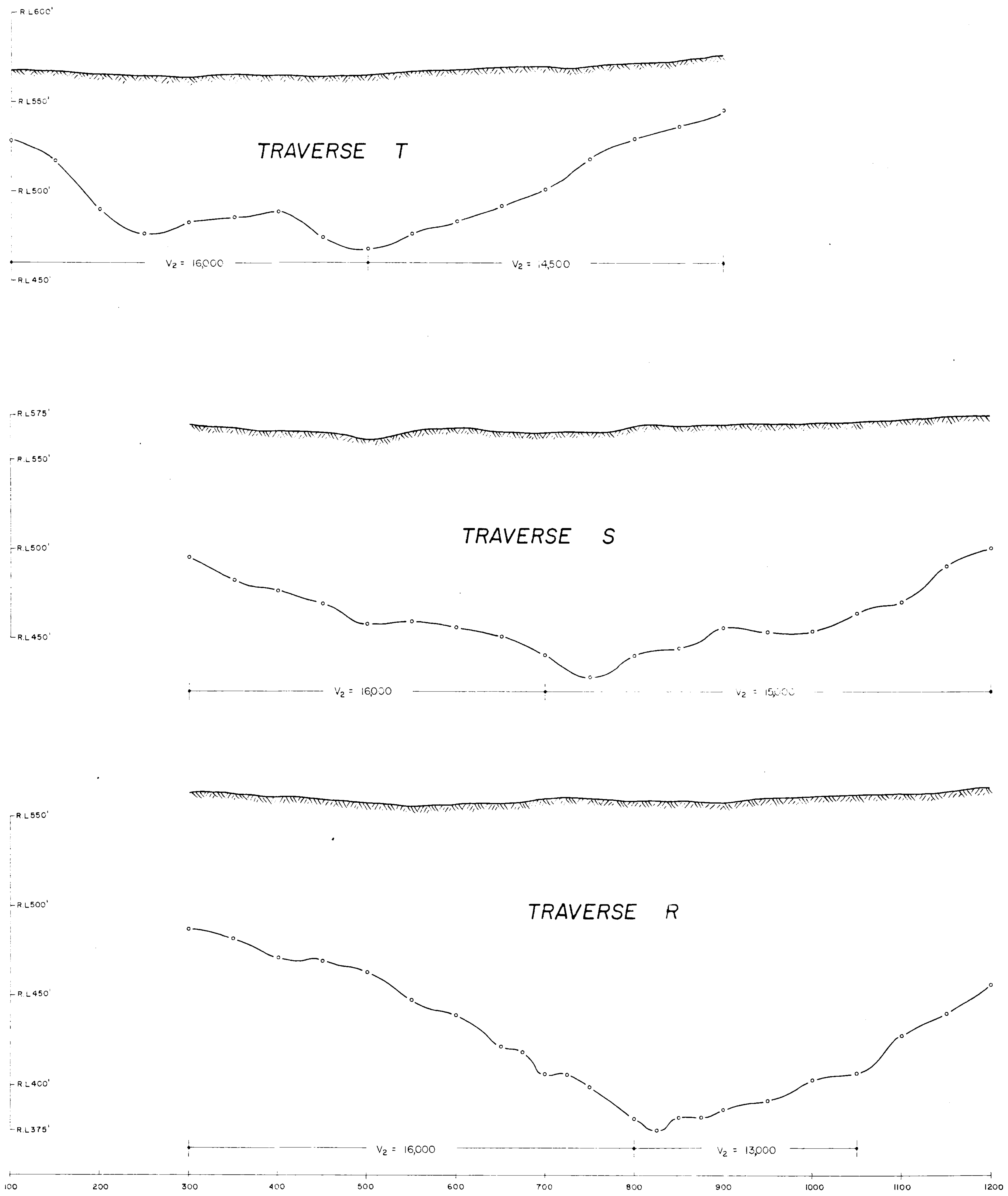
We may take the actual depth as that corresponding to the most probable density contrast. If the assumed density contrast of 0.6 is correct, the depth is slightly less than 100 feet. This is a little greater than that given by the seismic results, but the discrepancies may be lessened by the use of a more appropriate method of reduction.

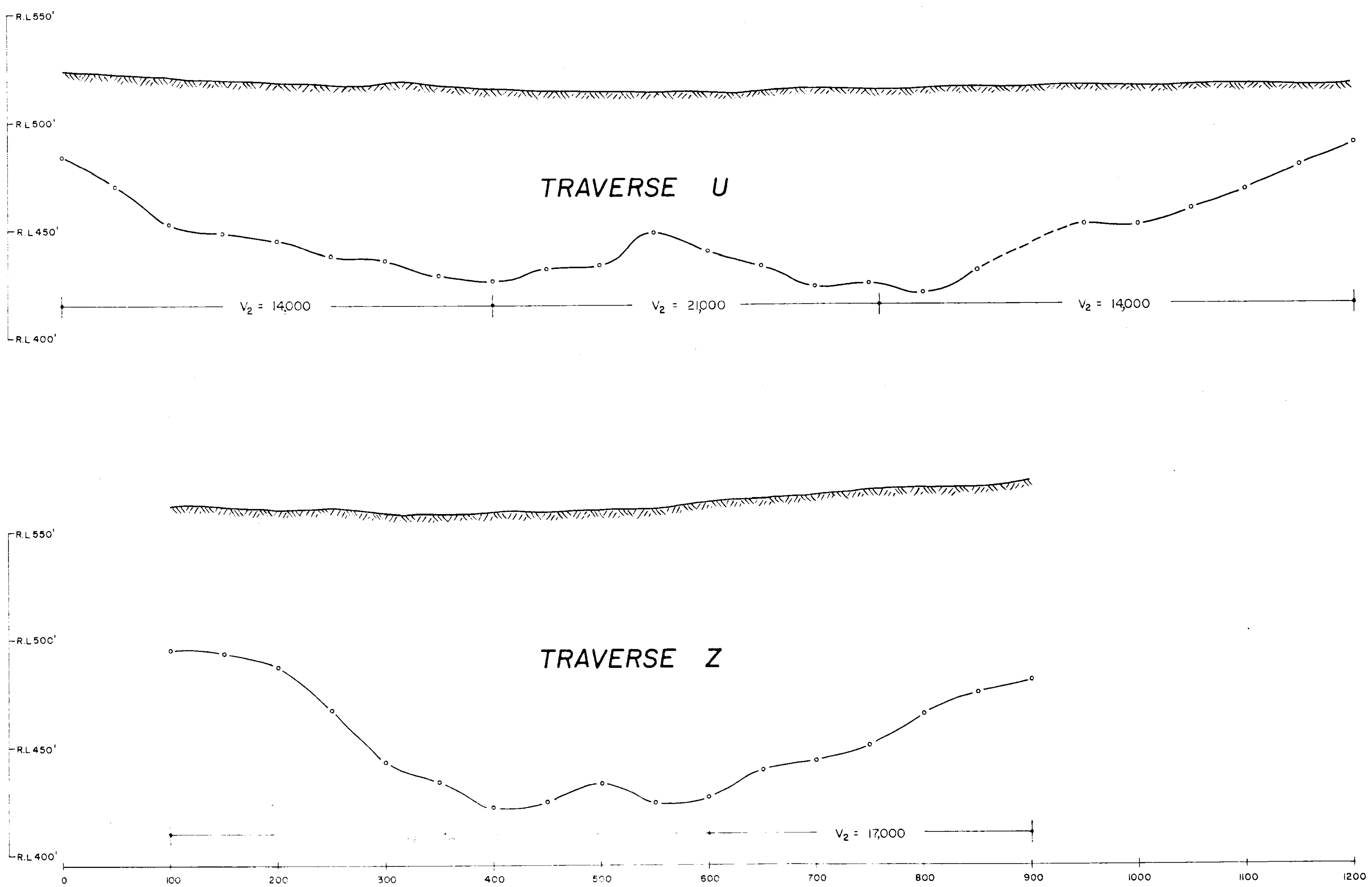
It seems that this method could be used to obtain an order of magnitude which would be useful in reconnaissance surveys.



GEOPHYSICAL SURVEY AT UPPER YITHAN TIN MINES, NEAR ARDLETHAN, N.S.W.

GEOPHYSICAL TRAVERSES, SURFACE CONTOURS AND FEATURES





GEOPHYSICAL SURVEY AT UPPER YITHAN ALLUVIAL TIN MINES,

NEAR ARDLETHAN, N.S.W.

PROFILES OF SURFACE AND UNWEATHERED BEDROCK

(FROM SEISMIC RESULTS)

SCALES IN FEET

Horizontal	100	0	100	200	300	400
Vertical	50	0	50	100	150	200

GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. G75-11

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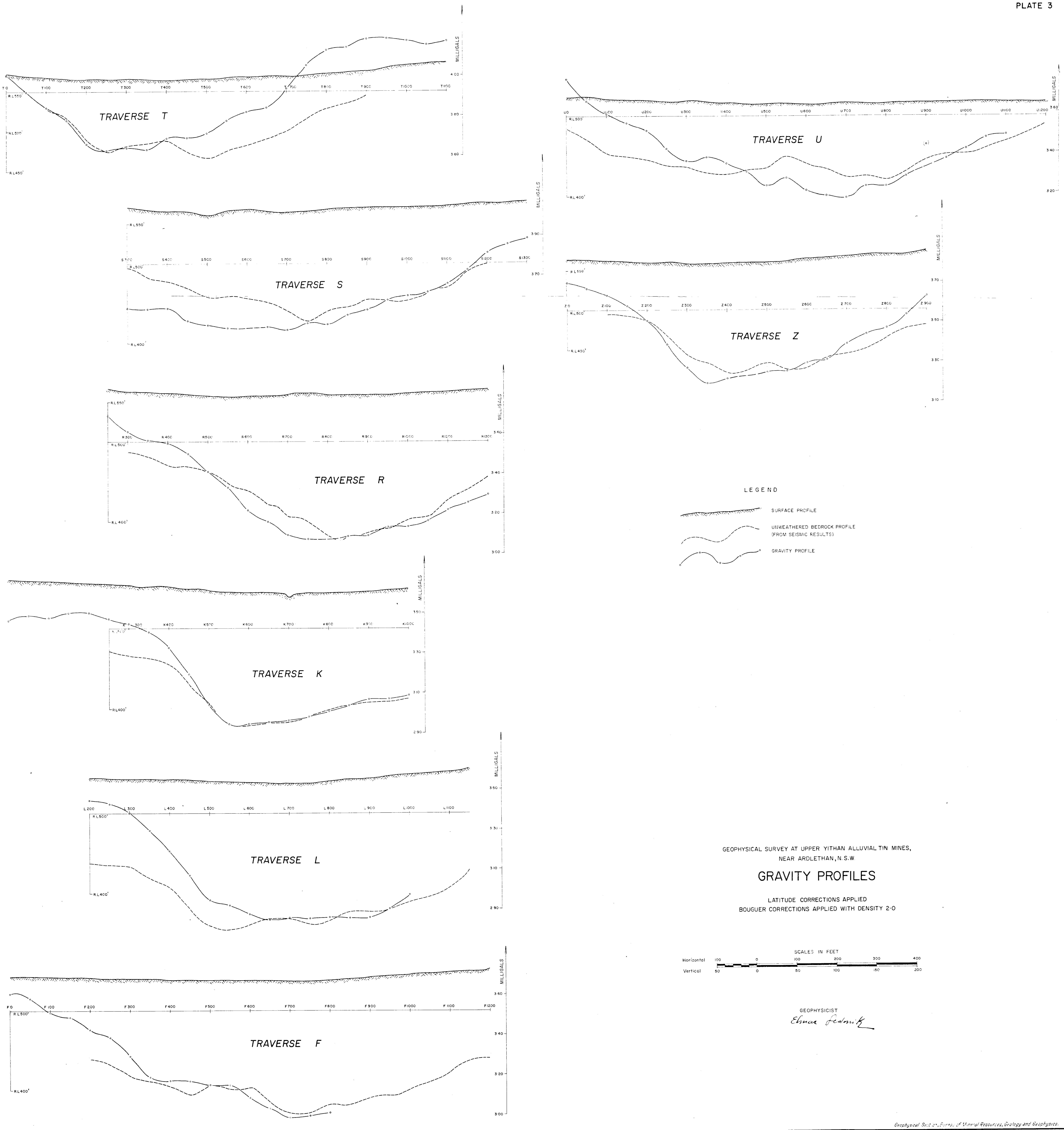
PLATE 3



GEOPHYSICAL SURVEY AT UPPER YITHAN ALLUVIAL TIN MINES,
NEAR ARDLETHAN, N.S.W.

GRAVITY PROFILES

LATITUDE CORRECTIONS APPLIED
BOUGUER CORRECTIONS APPLIED WITH DENSITY 2·0

SCALES IN FEET

Horizontal	100	0	100	200	300	400
Vertical	50	0	50	100	150	200

GEOPHYSICIST
Elmar Sedmik

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. G75-10
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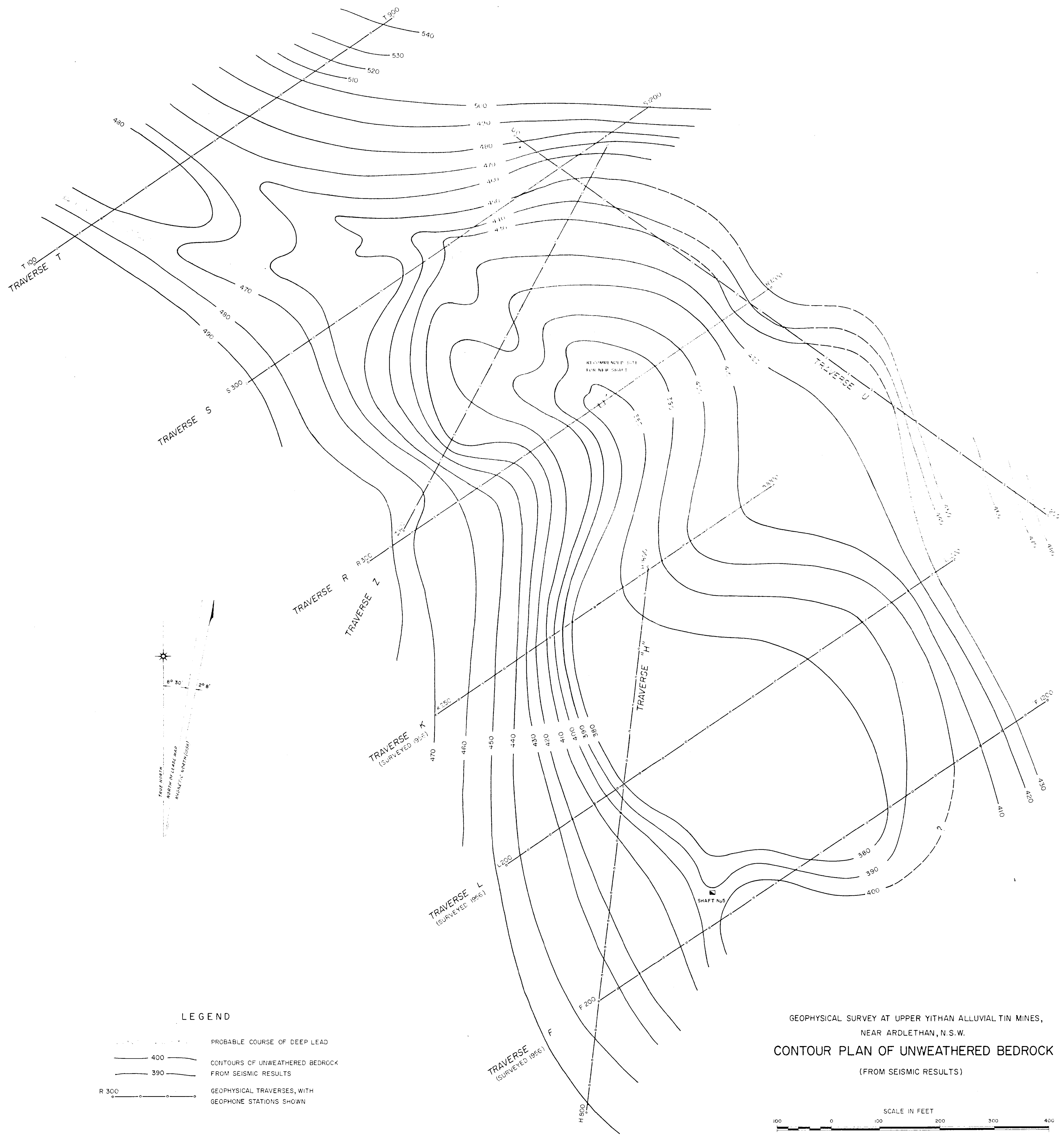

LEGEND

PROBABLE COURSE OF DEEP LEAD

400 / 390 — CONTOURS OF UNWEATHERED BEDROCK FROM SEISMIC RESULTS

R 300 — GEOPHYSICAL TRAVERSES, WITH GEOPHONE STATIONS SHOWN

GEOPHYSICIST

GEOPHYSICAL SURVEY AT UPPER YITHAN ALLUVIAL TIN MINES,
NEAR ARDLETHAN, N.S.W.

CONTOUR PLAN OF UNWEATHERED BEDROCK

(FROM SEISMIC RESULTS)

SCALE IN FEET

100 0 100 200 300 400

CONTOUR INTERVAL 10 FEET

NOTE: TRAVERSE Z CONCIDES APPROXIMATELY IN POSITION WITH TRAVERSE M OF 1956 SURVEY

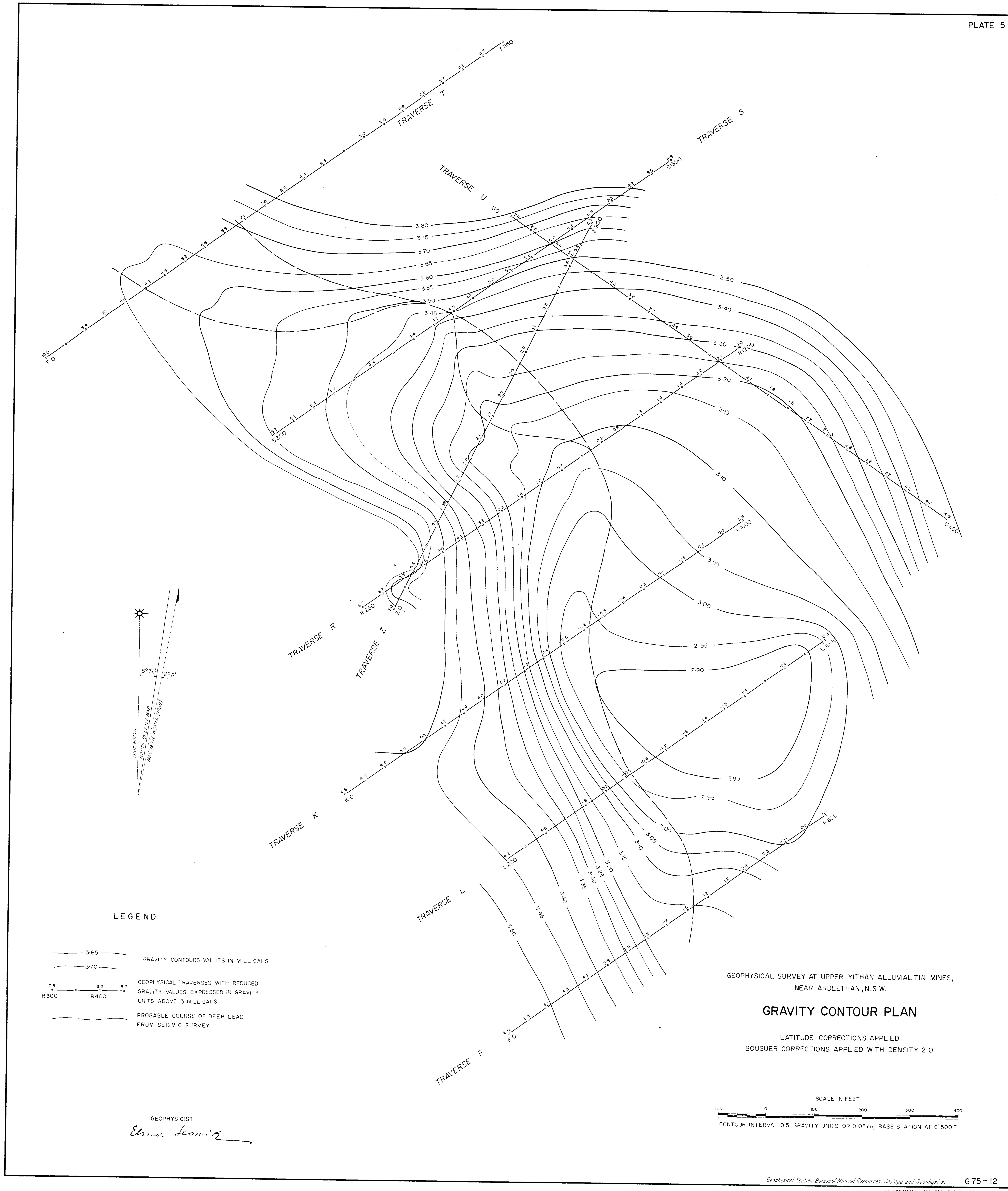
PLATE 5
TRAVERSE T
TRAVERSE S
TRAVERSE U
TRAVERSE R
TRAVERSE Z
TRAVERSE K
TRAVERSE L
TRAVERSE F
TRUE NORTH
NORTH OF LEASE MAP
MAGNETIC NORTH (1958)
8°30'
2°8'
LEGEND
3·65
3·70
GRAVITY CONTOURS. VALUES IN MILLIGALS
GEOPHYSICAL TRAVERSES WITH REDUCED GRAVITY VALUES EXPRESSED IN GRAVITY UNITS ABOVE 3 MILLIGALS
PROBABLE COURSE OF DEEP LEAD FROM SEISMIC SURVEY
GEOPHYSICAL SURVEY AT UPPER YITHAN ALLUVIAL TIN MINES, NEAR ARDLETHAN, N.S.W.
GRAVITY CONTOUR PLAN
LATITUDE CORRECTIONS APPLIED
BOUGUER CORRECTIONS APPLIED WITH DENSITY 2·0
SCALE IN FEET
100 0 100 200 300 400
CONTOUR INTERVAL 0·5 GRAVITY UNITS OR 0·05mg. BASE STATION AT C'500E
GEOPHYSICIST
Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics.
G75-12
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