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TALLEBUNG GEOPHYSICAL SURVEY FOR ALLUVIAL TIN, NSW 1961-1962

BY

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SUMMARY

Geophysical surveys were made at Tallebung, NSW in 1961 and 1962. Several deep leads of alluvial tin had been extensively mined and drilled there and had been shown to lie beneath the alluvium in depressions in the slate bedrock. The aim of the surveys was to trace the main depression beyond the known area by using several geophysical methods.

The 1961 survey consisted mainly of the seismic refraction method with some magnetic and resistivity work. A smaller party made a short gravity survey in 1962. The seismic and gravity methods proved useful and it was possible to predict the probable course of the lead for several miles. Resistivity and magnetic results were not useful for detecting bedrock depressions and are not included in this report.

Some preliminary drilling was done during the survey and the results were used in the interpretation of the geophysical work. Several additional drill sites are recommended.

1. INTRODUCTION

The Tallebung tinfield is situated 46 miles by road north-westerly from Condobolin (339 miles from Sydney on the Broken Hill railway) in the Parish of Urambie East, Country of Blaxland, NSW.

Tin was first reported from this locality in 1880 and since then both reef and alluvial tin have been worked. However, owing to many causes, such as lack of water and the low price of tin, mining was only carried on intermittently.

In 1961 the Tullabong Tin Syndicate Ltd was engaged in drilling and sampling two tin leads at Tallebung. This testing and the old alluvial mining had been concentrated mainly near the source of the tin. The NSW Mines Department requested a geophysical survey by the Bureau of Mineral Resources, Geology and Geophysics to assist in tracing the leads from where they were known to the broad flats north of the worked area.

The geophysical field work in 1961 occupied 16 weeks from 17th July to 6th November. Seismic, refraction, magnetic, and resistivity methods were used. The geophysical party consisted of geophysicists, M.J. O'Connor (party leader), R.J. Smith, and F. Maranzana, five field assistants, and a cook. The topographical survey of the traverse lines was carried out by surveyor J.P. Dynes of the Department of the Interior, Sydney, assisted by two chainmen. Owing to illness, Mr. Dynes was relieved near the end of the survey by surveyor A.N. Rochfort.

Early in 1962 it was decided to use the gravity method in the area to gain additional information, which it was hoped would help in the interpretation of the geophysical work done in the previous year. Geophysicists R.J. Smith and J.P. Williams and field assistant N. Ashmore made a gravity survey between 4th and 17th April 1962.

2. GEOLOGY

The geology of the Tallebung tinfield has been described by Carne (1911) and Raggatt (1939). The following notes are based on Raggatt's report.

The country rock in the tinfield consists of Ordovician sediments, mainly dark grey to black slates, with occasional thin white sandy bands. The regional strike is N30°W, and the dip generally west at 50 to 70 degrees. The sediments have been intruded on a large scale by the Erimeran granite, which covers large areas to the north, north-west, and south of Tallebung. The nearest outcrop of granite is about 1½ miles south of the tinfield.

Outcrop is confined to scattered ranges of low hills, surrounded by extensive soil flats. The sediments contain quartz reefs, carrying cassiterite and wolfram. It is noticeable that the granite in the immediate neighbourhood of Tallebung contains no tin, although the Erimeran granite is known to carry tin mineral-isation in several other areas.

Although a considerable amount of tin has been produced from small workings on the quartz reefs, the main reserves are contained in alluvial deposits. Old drainage channels under the alluvial flats contain cassiterite derived from the weathering of the reefs, and in several areas, these form deposits of high grade. Three such leads are known, and are referred to as the Southern, Central, and Northern leads (Plate 1). The first alluvial mining was at a depth of about 28 ft; however, this lead was on a false bottom and in 1937 deeper leads were found at depths of about 60 ft. The field is in an area of low and unreliable rainfall, and mining has been frequently hampered by shortage of water. For this and other reasons, previous mining has been selective, confined to high-grade ore. Construction of a pipe line from the Lachlan River has now provided an assured water supply which will enable large-scale systematic mining to be carried out.

3. METHODS AND EQUIPMENT

The geophysical methods used in the Tallebung survey were seismic refraction, magnetic, resistivity, and gravity. The applicability of these methods to the problem of detecting alluvial deposits has been discussed by Sedmik (1964).

The geophysical equipment used on the surveys consisted of:

Geophysical method	Instrument	Manufacturer	Type
Seismic	Portable refraction seismograph	SIE	PRO-11-6"
	Geophones	Electro-Tech	20 c/s
Magnetic	Torsion magnetometer (vertical force)	ABEM	Model 4, Ser.No. 4503
Resistivity	Geophysical megger	Evershed & Vignoles	0-30 ohm
	Resistivity meter	Bureau of Mineral Resources	Type A Ser. No. 2
	Tellohm meter	Nash & Thompson Ltd	Model G.P. Ser. No. 144
Gravity	Gravity meter	World Wide Instrument Inc.	Ser. No. 35

4. FIELD WORK AND RESULTS

The complete geophysical grid is shown in Plate 1. Its origin is on the north-west corner of ML12. Traverses 0 to 3000N, which are parallel and spaced 500 ft apart, run roughly east-west.

The seismic results along these traverses proved difficult to interpret. It was thought that these difficulties might be caused by the fact that in this area the traverses crossed the general strike of the slates and quartzites which have undergone varying degrees of weathering. It was decided to change the direction of the traverses and to work back from a gap in the hills north-east of Tallebung towards Traverse 3000N (see Plate 1).

Traverse A was laid down across the gap and Traverse B was set parallel to Traverse A and 500 feet away. Traverses C, D, E, and F were then placed parallel to Traverse B and separated by 1000 ft. These traverses are roughly parallel to the regional strike of the rocks. Two traverses, viz. Traverses G and H, were placed between Traverses F and 3000N as shown in Plate 1. Traverse Z was run perpendicular to Traverse B from B5000N.

The total length of traverses covered by the seismic method was 14 miles. The seismic work consisted of:

(a) Weathering spreads to obtain the seismic wave velocities in the soil and near-surface layers. Geophones were spaced at 5 and 10-ft intervals and shot-points were placed in line with the spread at distances of 5 ft, 50 ft, and in places up to 150 ft, from each end of the spread,

(b) Normal spreads to determine the time taken for the waves to travel from the surface to the bedrock and back to the surface and also to measure the velocities in the formations beneath the soil. Geophones in these spreads were spaced at 50-ft intervals and the shot-points were placed in line with the spread at distances ranging from 25 ft to 1000 ft from either end of the spread.

It was found after some experimental shooting at Tallebung that calculation of a continuous profile of the bedrock from the seismic results required considerable over-lap of geophone spreads. The most suitable over-lap was found to be 250 or 300 ft.

(c) Borehole and shaft velocity logging to measure directly the average seismic velocity (vertical direction) in the overburden between the shot-point and the surface. Shots were fired in boreholes and shafts and times were measured to geophones on the surface near the collar of the holes or shafts. Shots were generally placed at the bottom of, and at regular intervals up, each borehole or shaft.

Vertical travel times (VTT) were computed at each geophone station for normal spreads by using the method of differences. The VTT were converted to depths using the mean time/depth curve derived from the results of the shots at various depths in the bore-holes and shafts. A correction was applied to compensate for variations in the thickness of the low-velocity surface layer. An average velocity of 1000 ft/sec was assumed for this layer, based on the measurements with weathering spreads.

These results are shown as solid lines on the seismic cross-section of Plates 2, 3, and 4 and the bedrock contours derived from them are shown in Plate 5. Depth estimates were also made using the intercept times and the standard method of computing depths to various refractors (Hawkins, 1961). This was done wherever possible and the results, together with the velocities used in the computations, are also shown in Plates 2, 3, and 4 for comparison with the results from the time/depth curves.

Gravity

Gravity measurements were made on seismic Traverses 1000N, 3000N, H, G, F, D, B, A, and Z, and on one new traverse (Traverse X) which was pegged and levelled by the geophysical party. Altogether 44,000 ft of traverse were surveyed with the gravity meter.

The area is flat and easily accessible by Land-Rover so that one main base (D4200N) and one sub-base (3000N/1200W) provided sufficient control over the whole area. Most traverses were surveyed at 100-ft intervals between observation points but some measurements were made at 50-ft intervals in interesting areas. Readings were taken at either the main base or the sub-base approximately every hour and several checkpoints were also read at short intervals along the traverse in order to have sufficient control over the drift of the instrument. On several occasions where a steep or irregular drift was observed, readings were repeated on another day.

Samples were taken of the overburden, and the weathered and unweathered bedrock for density measurements. The mean density of unweathered bedrock was determined at 2.6 ± 0.1 g/cm^3 Samples of overburden were taken about 1 ft below the surface to avoid topsoil effects (loose pebbles, grass roots, etc.) but the density determinations of these samples showed a considerable range of values and could not be regarded as reliable. It was decided to adopt a density of 2.0 g/cm^3 for the overburden.

The gravity results were corrected for instrumental drift, elevation, and latitude; a Bouguer anomaly profile was drawn for each traverse. The profiles were then used to draw a Bouguer anomaly contour map. The contour map showed little evidence of a depression going through the area and did not appear to be consistent with drilling results.

It was reasonable to expect that the deeper geological structure would have some effect on the gravity results and this was particularly evident on Traverses 1000N and 3000N where a gravity 'high' coincided with the position of the lead as shown by drilling. The most important part of the gravity interpretation was the separation of the effect of variations in density of the bedrock and regional gravity variations.

In order to separate the two effects it was first necessary to construct a gravity map (referred to as a 'bedrock' gravity map) which was not affected by the presence of the old river valley. Points near outcrop or known shallow bedrock were selected from the Bouguer contour map and used as a basis for the bedrock gravity contour map. Additional information was obtained from boreholes and shafts throughout the area. Where the depth to bedrock was known, the effect of that thickness of overburden could be calculated (assuming a density contrast of 0.5 g/cm^3 between overburden and bedrock) and removed from the elevation-corrected gravity at that point. This gave several additional points on the gravity map and a contour map was drawn using all such available information (Plate 6). The difference between the Bouguer contour map and the bedrock gravity map should then be due to the presence of the old river valley; a residual gravity map should indicate the course of the valley. It must be emphasised that the borehole data, which it has been necessary to use to obtain most of the bedrock gravity values, may not be reliable with regard to depth to bedrock. If these borehole data are not reliable an error is introduced. The complex nature of the bedrock gravity data also limits the accuracy of the gravity interpretation. Between Traverses A and F the bedrock gravity contours are simple and regular but they become increasingly complex towards the southern part of the area. It is not possible to map accurately such a complex field with the few scattered points available and for this reason Traverse 1000N has been omitted from the bedrock and residual gravity maps.

The bedrock gravity values (Plate 6) were subtracted from the Bouguer gravity values to give the residual gravity values which were contoured (Plate 7). This residual gravity map should show the position of the old river valley and the value of residual gravity should be roughly proportional to the depth to bedrock. This estimate of depth should be more accurate over the lead than over shallow bedrock as the elevation corrections (based on a density of 2.0 g/cm^3) should be more appropriate over the lead.

The residual gravity map shows a main depression that can be traced through the whole surveyed area with several possible tributaries. Generally the residual gravity contours show a close resemblance to the bedrock contours derived from seismic work, but with some minor differences that will be discussed later.

Magnetic

Magnetic readings were made along Traverses 00, 500N, and 1000N at 50-ft intervals except between 1600W and 300W along Traverse 500N where readings were taken at 25-ft intervals.

Resistivity

Using the Wenner configuration of electrodes, the following resistivity work was done:

Depth probes

Depth probes were made at five boreholes in the southern part of the area.

Constant electrode spacing

Traverse	Electrode spacing (ft)
740S	50
00	50
500N	100
1000N	50
2500N	50,100
A	100

A larger electrode spacing than actually used would have been desirable but the low resistivity values encountered did not permit use of 150 and 200-ft spacings which would have been more appropriate for the thickness of overburden in this area.

5. INTERPRETATION OF RESULTS

Seismic

The seismic velocities measured during the survey at Tallebung may be classified into four groups as follows:

Group	Longitudinal velocity (ft/sec)	Rock type
1	500 - 1500	Top soil
2	2500 - 6000	Alluvium
3	5500 - 12,000	Weathered slate
4	12,000 - 17,000	Slightly weathered to unweathered slate.

The leads have been shown by mining and drilling to lie under the alluvium in old river channels or depressions in the soft slate bottom. The measured seismic velocities in the weathered and fresh slate vary markedly along each traverse (see Plates 2, 3, and 4), probably owing to variations in the degree of weathering and also in the thickness and frequency of bands of quartzite that occur in the slate. The velocities measured in the weathered and unweathered bedrock were generally greatest in the striking direction of the beds, i.e. the velocities measured along Traverses A, B, C, D, E, and F (which were laid out parallel to the general striking direction of the country rocks) were in general greater than the velocities measured along the Traverses 00 to 3000N, G, H, and Z.

The high-velocity layer (12,000 - 17,000 ft/sec) corresponding to the unweathered bedrock has not been used in determining the probable course of the lead. This is because preliminary results (seismic) indicated such a great depth of weathering in the bedrock that the unweathered bedrock boundary was not considered to be of any immediate interest in tracing the deep lead. The high-velocity refractor is therefore not included in the seismic cross-section in Plates 2, 3, and 4, except on Traverses A and H, where it is shown to illustrate the nature of the results obtained.

A study of the time/distance curves and seismic cross-sections and a comparison of the few drilling results with the seismic results shows:

(a) There is a considerable thickness of very weathered and weathered bedrock,

(b) The ratio of velocities in weathered bedrock and in overburden is less than the ratio of velocities in unweathered and weathered bedrock.

In many places at Tallebung it is often difficult to determine the depth to weathered bedrock by drilling because the bedrock is softer than the overburden owing to the very strong weathering. This strong weathering and consequent low velocity-contrast has seriously hindered the seismic interpretation and limited the extent of any conclusions that can be drawn from it.

An interesting feature of the comparison between depths calculated from intercept times and from the method of differences using the time/depth curve is the reasonable agreement along Traverses A to F, which are parallel to the strike of the slates. Along these traverses the seismic survey indicated a more-pronounced velocity contrast between overburden and weathered bedrock. Along the traverses crossing the strike of the slates the depths from intercept times are much greater than those from the method of differences using the time/depth curve. There is some evidence in the time/distance curves and the velocity logs to suggest the presence of a low-velocity layer within the overburden. The velocity log of borehole No. BT4 (situated at 3600N, 600E on the geophysical grid) shows evidence of this and the time/distance curves on Traverses 2000N, 2500N, and 3000N also suggest it. The evidence is far from conclusive but, if such a low-velocity layer exists, it could cause the seismic results to predict a greater depth to bedrock than the true depth. This would apply particularly to the intercept method which does not use any vertical velocity determinations; however, both methods would be affected to some degree.

The seismic contour map (Plate 5) has been constructed from the profiles obtained using the time/depth curve. The depths from intercept times have not been contoured, as over half the area they are considered unreliable and in the other half of the area they are in close agreement with the contoured values.

The contour plan of the weathered slate surface (Plate 5) which was drawn from the seismic results, shows many interesting features:

(a) In the weathered slate surface a depression is indicated that can be traced from Traverse 00 through to the other end of the surveyed area at Traverse A. It appears likely that the main deep lead at Tallebung is associated with this depression which runs roughly north-westerly from Traverse 00 to Traverse 2000N where its direction swings around to northerly; the direction from Traverse 3000N to Traverse F is north-easterly. East of Traverse F the direction of the indicated depression swings more to the north and follows a slightly sinuous course through to Traverse A,

(b) This main depression has a gentle fall from Traverse 00 to Traverse 2500N, is relatively flat between Traverses 2500N and H, and then there is a steeper downward gradient between Traverses H and G. Between Traverses G and A the indicated depression remains relatively flat,

(c) Two minor depressions coming from the north-west between Traverses E and A cross Traverse Z. These depressions, which probably combine with the main depression between Traverse B and D, come from a relatively short valley between two lines of hills and are not considered to be of any importance as tin prospects,

(d) A large depression coming from the south-east runs along Traverse D. It probably joins the main depression between Traverses D and E. There is no reason to expect this depression is tin-bearing as no primary tin deposits are known in the bedrock outcrops in the neighbourhood,

(e) A small, shallow depression cuts across the eastern ends of Traverses 500N, 1000N, and 2000N. This depression runs slightly west of north and is known from mining and drilling to carry low tin values. It probably joins the main depression between Traverses G and H,

(f) A ridge in the weathered slate along Traverse E is probably associated with the slate hills between Traverses G and F.

Gravity

The bedrock gravity map (Plate 6), based largely on borehole data, shows some surprising features. North of Traverse G the bedrock gravity contours are regular and evenly spaced but, in the southern part of the area, between Traverses G and 1000N, the bedrock, gravity contours show relatively steep gradients and irregular shapes. The most significant feature of this map is the steep bedrock gravity gradient between the eastern ends of Traverses G and 3000N. Although this is based on a few widely scattered points, the values have been carefully checked and there is little doubt that the steep gradient really exists. This feature could be caused by the presence of a fault zone which, if it continues to the west, could also explain a steep gradient between the western ends of Traverses 3000N and H.

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Between Traverses 3000N and 1000N very little data on the bedrock gravity gradient is available. The available information indicates a steep, regular gradient but Traverse 1000N was disregarded because of insufficient data. North of Traverse G there were no peculiarities and the bedrock gravity values should be reliable.

The residual gravity map (Plate 7), obtained by subtracting the bedrock gravity values from the observed values, shows a general similarity with the seismic contour map (Plate 5). The main gravity depression could be traced through the area from Traverse 3000N to Traverse A following a similar course with some deviations, to the bedrock depression indicated by the seismic survey. Both geophysical methods indicate a generally broad and poorly defined depression. As few traverses were used to cover a large area, especially with the gravity method, contouring involved considerable interpolation.

The main residual-gravity depression intersects Traverses 3000N, H, F, and A at the same points as the bedrock depression shown on the seismic contour map. There are discrepancies on Traverses G, D, and B but only on Traverse D is the discrepancy large.

On Traverse G the gravity depression is about 500 ft east of the seismic depression. The depression there is not well defined by either method (seismic or gravity) so further drilling would be needed to position the lead there.

The main difference between the two maps (seismic and residual gravity) is the position of the depression on Traverse D. The seismic work indicates a broad, poorly-defined bedrock depression at about 2000N where there is a slight residual gravity 'high'. The seismic and gravity profiles are both relatively flat and it seems unlikely that the difference between the two methods can be resolved.

The gravity depression on Traverse B is narrow and well-defined at 3900N which is 400 ft away from the seismic depression indicated at 4300N. The seismic depression is less well-defined and the difference in location can easily be attributed to experimental error.

The residual gravity contours show a basin-like depression on the main lead between Traverses H and G, corresponding to a sharp change in gradient of the bedrock indicated on the seismic map. The part of the lead immediately below the steep gradient would have been a favourable area for the accumulation of tin and the fact that traces of tin have been found in a boreholes on Traverse G indicates the advisability of further drilling.

The residual gravity contours also show depressions on the eastern end of Traverse D and near 2000W on Traverse Z, where the seismic contour map indicated possible tributary bedrock depressions. However, these tributaries are not expected to be tin bearing since there are no known tin deposits in the slates in this area.

12.

Magnetic

The magnetic profiles showed only some small irregular magnetic variations due to very near-surface magnetic materials and were of no assistance in detecting the presence of a deep lead. This was not unexpected in this particular area. The results are not illustrated in this report.

Resistivity

The main feature of the resistivity results was the abnormally low specific resistivities encountered. Owing to low resistivities, reliable measurements could not be made with potential-electrode spacings greater than 100 ft. This was the major reason for the failure of the resistivity methods to assist in locating the deep leads. Over most of the area covered by the geophysical survey, the depth to the lead would be greater than 100 ft.

The results of some of the resistivity depth-probes in shallow alluvial ground (centred on boreholes where the depth to weathered slate was known) suggested that the depth to the weathered slate could be determined by this method. However, owing to lack of rain, the surface conditions were extremely dry and very few reliable measurements could be made.

The resistivity results are not illustrated in this report.

6. CONCLUSIONS AND RECOMMENDATIONS

The seismic refraction method was able to detect depressions in the weathered slate surface. Tin-bearing deep leads could be associated with these depressions. The geophysical methods cannot give any indications of a possible tin content in the leads.

The seismic results indicate that the most probable areas for accumulation of alluvial tin would be:

(a) near 2000N/500W and 2500N/100W,

(b) around G1500W and towards F900N where there is a sharp turn in the depression indicated in the weathered slate, and

(c) near B4400N where there should be a junction of several depressions in the weathered slate.

It is recommended that boreholes be put down in these areas and the recovery from the holes tested for tin content. It would be advisable to bore several holes in each area *e.g.* holes could be put down at 100-ft intervals across the recommended sites.

The first two areas should be tested first. The third area is a large distance from the primary tin deposits at Tallebung and it is probable that little or no tin would have been carried along the lead as far as Traverse A. In the slates of the north-western part of the area there are no known tin occurrences that could have fed tin into the depressions coming from the north-west between Traverses F and A, and consequently the tin content of the lead between Traverses F and A would be very diluted.

No additional drilling sites could be inferred from the gravity results. However, some conclusions drawn from the seismic work were strengthened. Three holes have now been drilled on Traverse G at 1250W, 1400W, and 1550W (see Plate 5) with traces of tin in at least two of them. Some further drilling in this vicinity would be warranted.

The shaded area in Plate 1 shows the zone where it is considered most probable that the deep lead occurs. This shaded zone is derived from a combination of seismic and gravity results and contains the main depressions shown in Plates 5 and 7.

The resistivity method could not be tested fully because of the unfavourably dry conditions. These dry conditions would probably always hinder resistivity field work at Tallebung.

7. REFERENCES

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SEDMIK, E.C.E.	1964	Winnaleah area geophysical survey, Tasmania 1961-62. Bur. Min. Resour. Aust. Rec. 1964/54 (unpubl.)

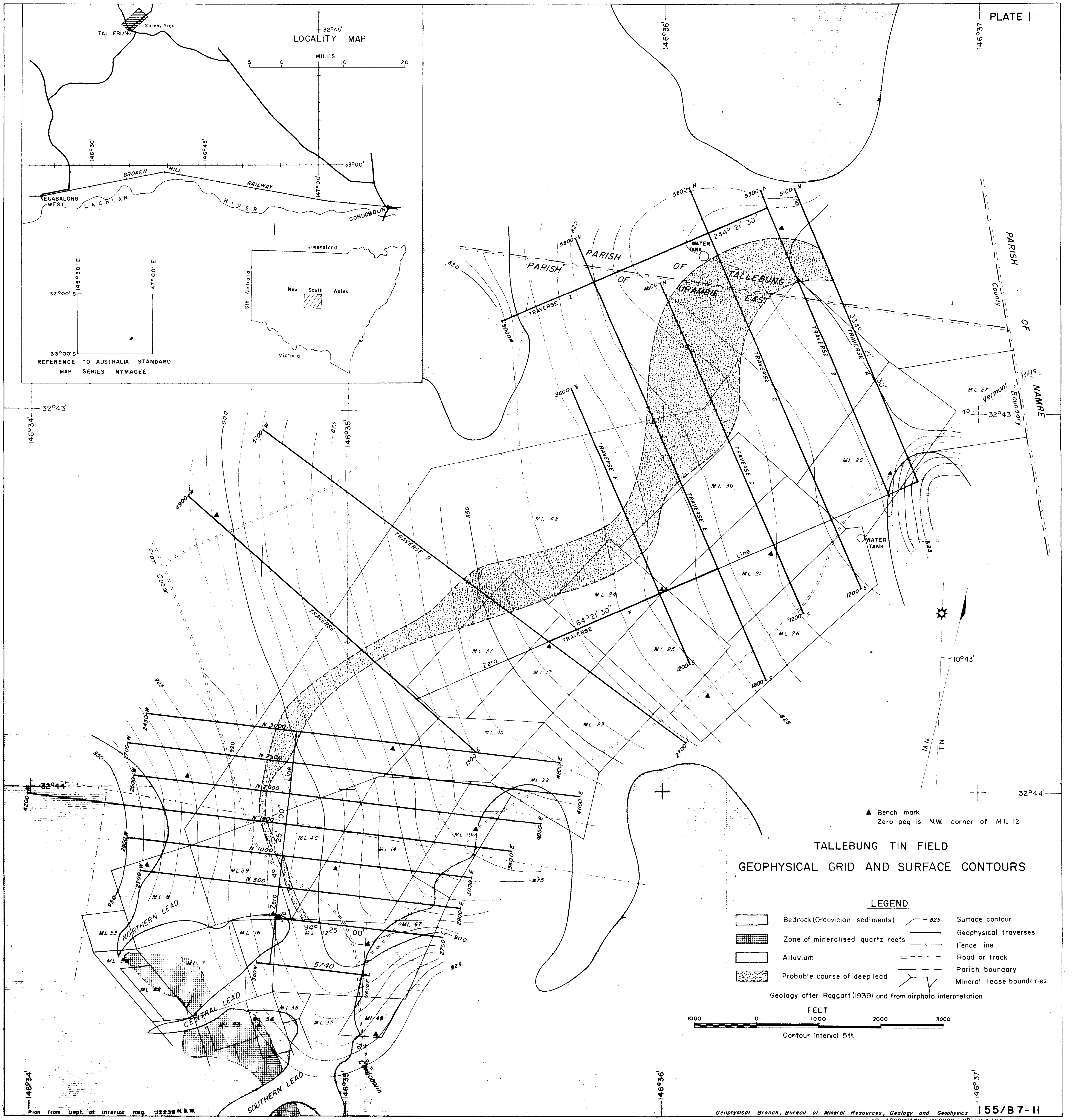

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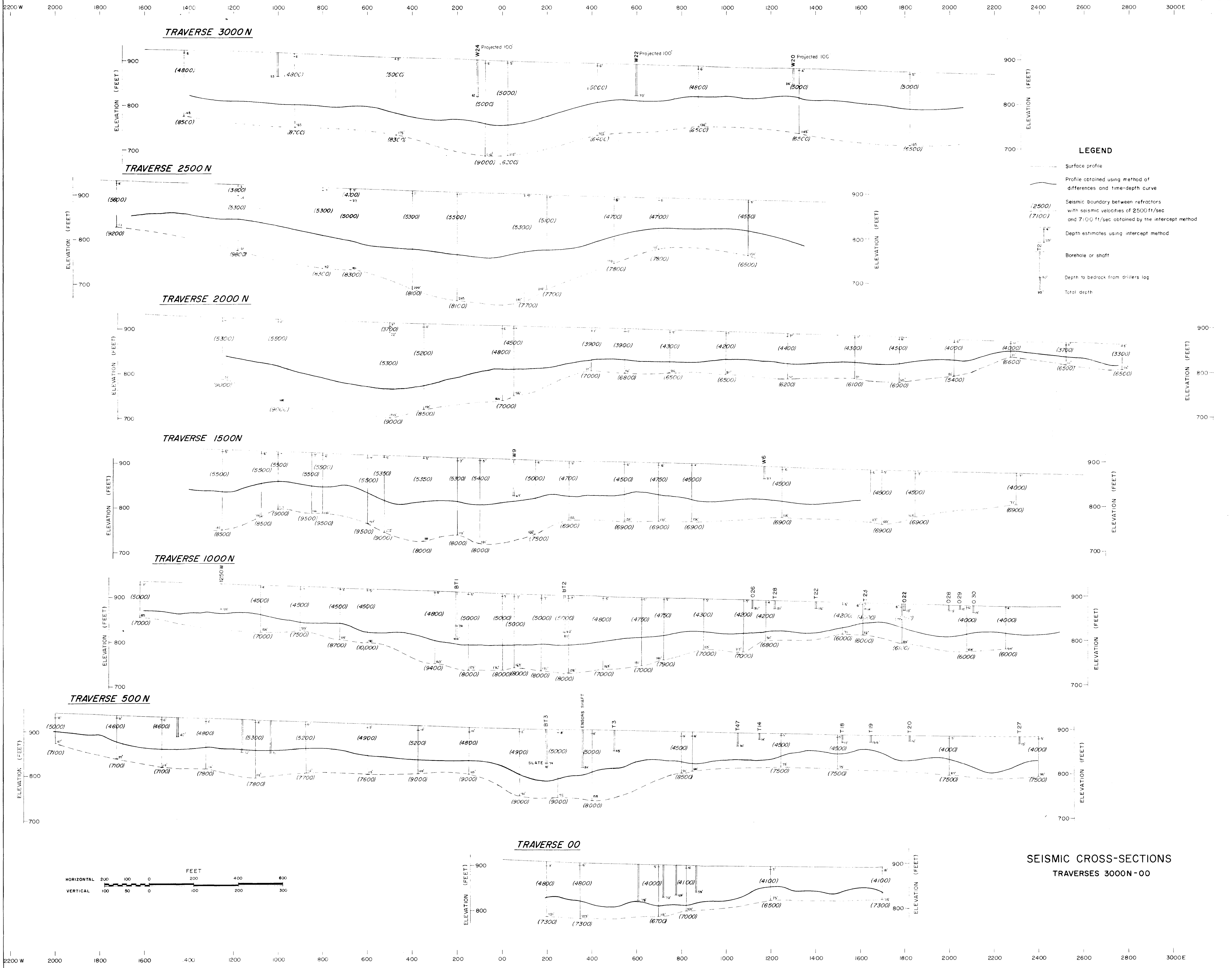
PLATE 2



SEISMIC CROSS-SECTIONS

TRAVERSES 3000N-00

SEISMIC CROSS-SECTIONS

TRAVERSES A,B,C,D,E, AND F

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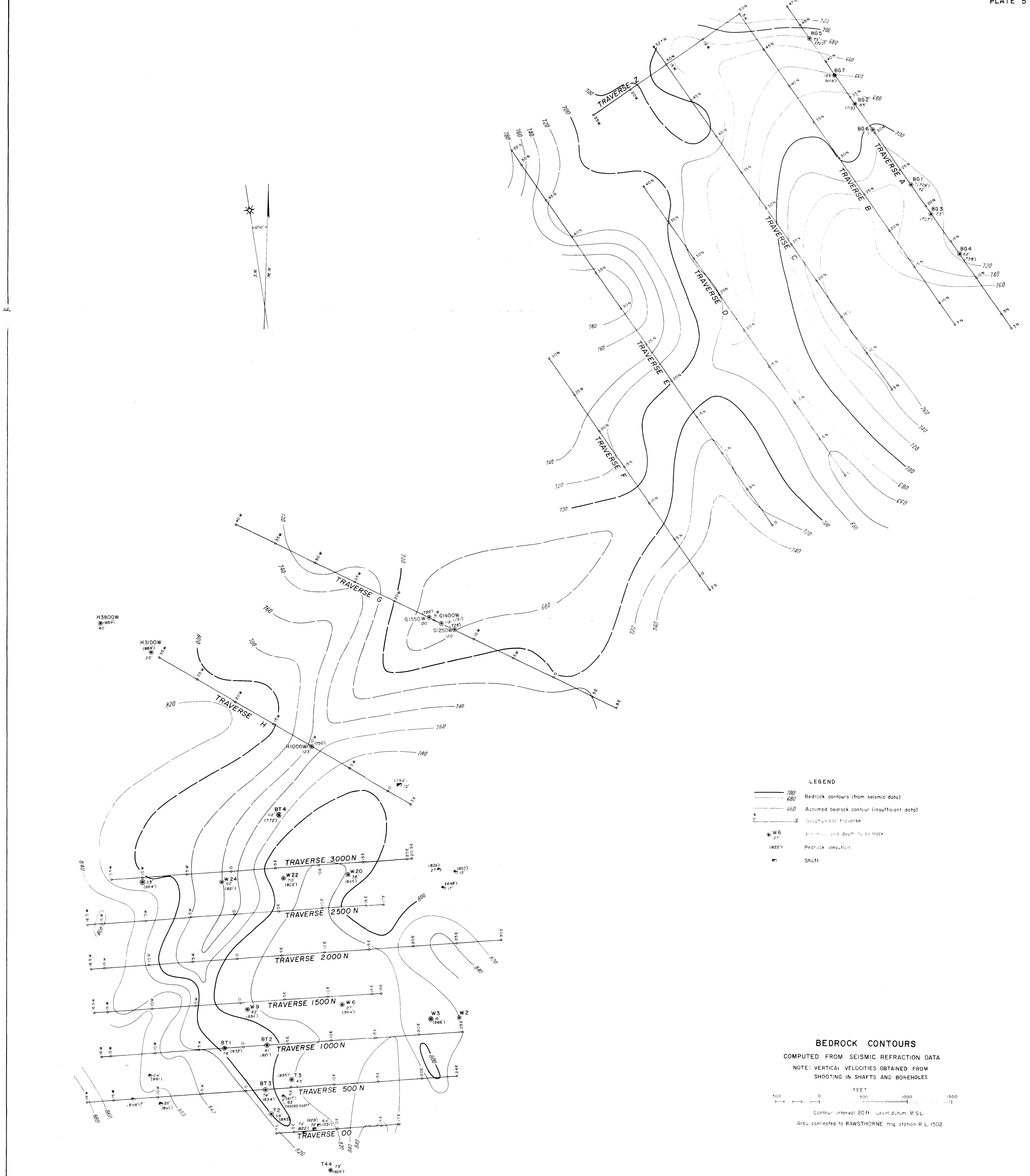
TALLEBUNG TINFIELD N.S.W.

To accompany Record 1964/84



BEDROCK CONTOURS

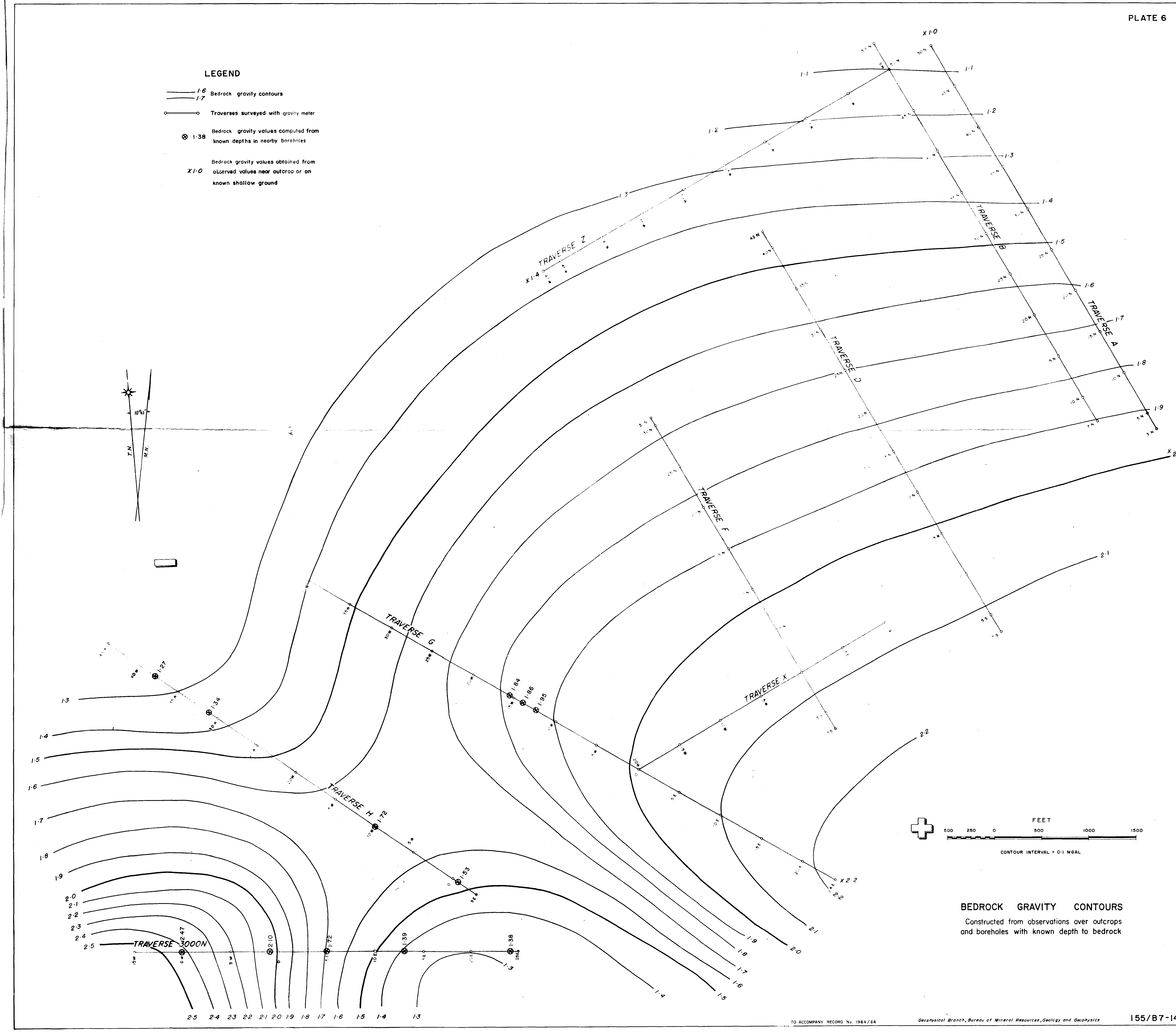
COMPUTED FROM SEISMIC REFRACTION DATA

NOTE: VERTICAL VELOCITIES OBTAINED FROM SHOOTING IN SHAFTS AND BOREHOLES

Contour interval 20 ft. Level datum: M.S.L.

Area connected to RAWSTHORNE trig. station R.L. 1502

TALLEBUNG TIN FIELD, N.S.W.



BEDROCK GRAVITY CONTOURS

Constructed from observations over outcrops and boreholes with known depth to bedrock

TALLEBUNG TIN FIELD, N.S.W.

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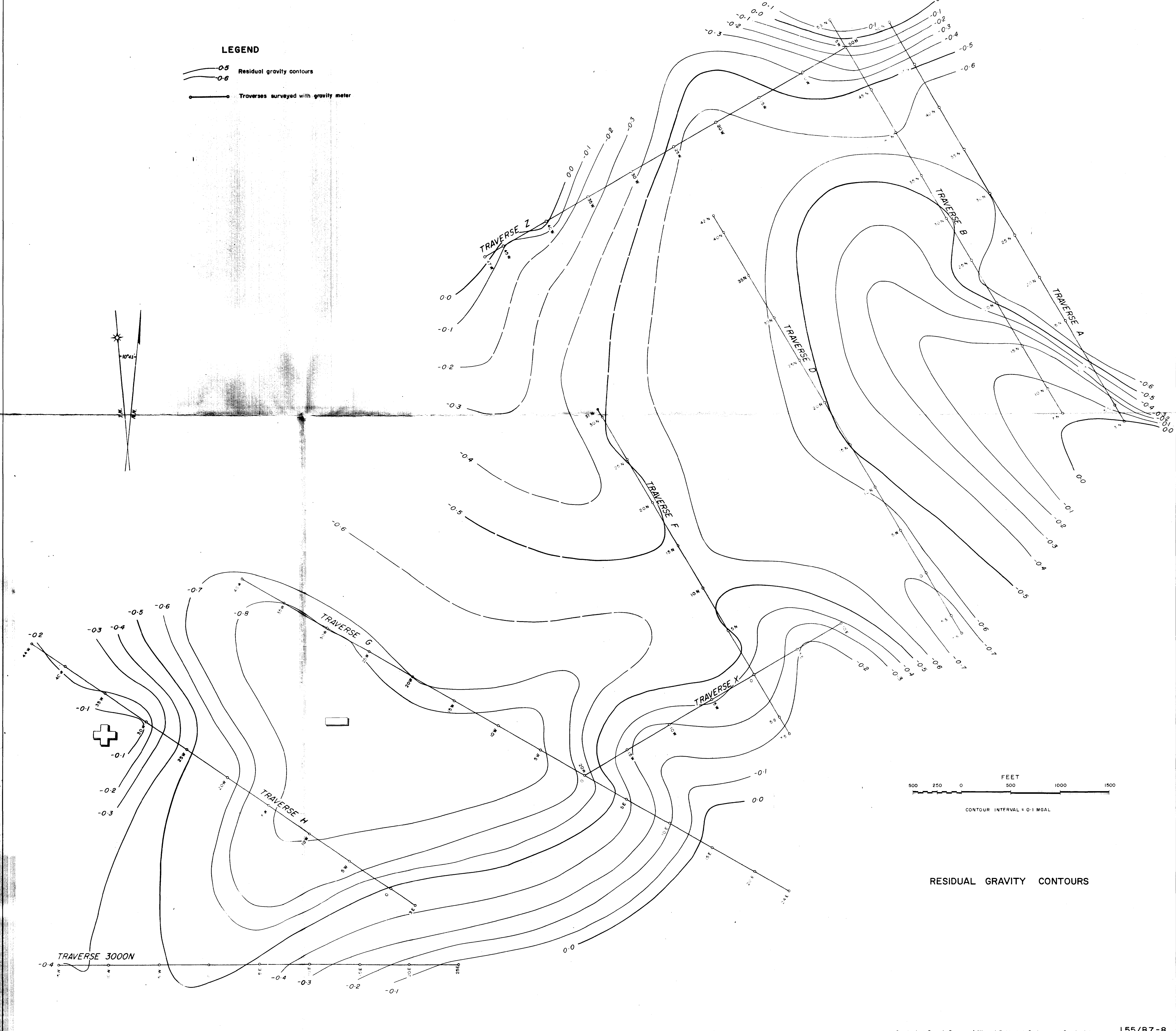
PLATE 7



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