COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

**BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS**

**RECORD No. 1966/10**

# DERBY-WINNALEAH GRAVITY SURVEY,

**TASMANIA 1964**



*by*

*A.W. HOWLAND-ROSE*

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## ILLUSTRATIONS

## SUMMARY

A gravity survey of the Ringarooma Valley between Derby and Winnaleah in north-eastern Tasmania was made by the Bureau of Mineral Resources during the period January to April 1964. The aim of the survey was to assist the search for tin-bearing deep leads and in particular to trace the extension of the Cascade deep lead and locate its junction with the main Ringarooma deep lead.

The interpretation of the gravity results is rendered uncertain in the northern part of the area by an unknown and perhaps variable thickness of basalt and by possible variations in the density of the basalt, and in the south by large terrain effects, which could not be determined accurately because of incomplete topographical information.

Several gravity low features were revealed, which may be due to the presence of deep leads. Drilling has been recommended in three areas of interest. Information gained from such drilling may lead to a more accurate evaluation of the results of the survey.

## 1. INTRODUCTION

Alluvial tin mining in north-eastern Tasmania reached its peak in the early part of this century, but has declined in importance since then, as most of the mines have been closed because the grade of the deposits was too low for economic operation. However, owing to the present high price of tin and the expectation of continued high prices, many of these deposits may now be profitably worked.

Rich deposits of alluvial tin in the form of deep leads were discovered in the Ringarooma Valley. The largest producer was the Cascade lead situated adjacent to the township of Derby. This lead, which was worked in the Briseis mine, yielded some 28,000 tons of tin concentrates up to 1961. Mining was discontinued in 1962 and has not been resumed since. The workings are now flooded. The Cascade lead was presumed to continue to join the main Ringarooma lead, but both the continuation and the junction with the main Ringarooma lead are concealed by several hundred feet of sediments and basalt and cannot be located from geological evidence. In 1964, at the request of the Tasmanian Mines Department, the Bureau of Mineral Resources (BMR) made a gravity survey of the area between Derby and Winnaleah, with the aim of tracing the continuation of the Cascade lead and, if possible, locating its junction with the Ringarooma lead.

The gravity method was regarded as the only geophysical method likely to be applicable to the problem. The seismic refraction method, commonly used in the investigation of deep leads, was not suitable for this work because of the overlying basalt.

The gravity work was done by A. W. Howland-Rose (geophysicsit) and N. Ashmore (field assistant) between January and April 1964. The traverses were pegged and levelled by D. J. Sheaves and two chainmen from the Department of the Interior, Canberra.

## 2. GEOLOGY

The geology of the Ringarooma Valley area has been described in detail by Nye (1925) and a summary of the general geology of the region has been given by Jack (1961). The geology shown in Plate 2 is mainly due to Nye, but incorporates minor modifications based on observations made during the geophysical survey.

The oldest rocks in the area are the sandstones and slates of the Mathinna Group, which are regarded as of Silurian age. They are intensely folded and faulted and are intruded by granite of probable Devonian age, which is now exposed in the southern and eastern parts of the survey area. The texture of the granite ranges from fine-grained to coarsely porphyritic. There is some local development of greisen and pegmatites. These veins and the granite itself are the source of the alluvial tin.

No Permo-Carboniferous rocks are present in the area. They occur to the north and south and were probably removed from the area during the long period of denudation and stream development that began after the close of the Permo-Carboniferous sedimentation. During this period of erosion, the ancient Ringarooma River system became established.

In Lower Tertiary times a relative depression of the land surface occurred and sediments from the streams gradually filled up the old valley. Cassiterite-bearing alluvium was deposited in the valley floors and formed the main leads.

The Lower Tertiary closed with the extrusion of basalts, which, in the survey area, include at least three flows of total thickness of about 200 feet. Adjacent to the Briseis mine these rest on about 300 feet of Tertiary sediments. The land was elevated at or immediately succeeding the time of the basaltic lava flows. The basalt had not completely filled the old Ringarooma River and the drainage system was able to re-establish itself in the former valley. The present Ringarooma River has not cut down its course to the level of the older one. It crosses the southern part of the survey area along a course close to the granite-basalt boundary and now rests for the most part on Tertiary gravels and clays.

The leads mined in the Ringarooma Valley are all situated on the south and south-east sides of the valley and are believed to be tributaries of the main Ringarooma lead. The Cascade lead as worked in the Briseis mine followed a general north-westerly course. The course of the lead beyond the old workings and its junction with the Ringarooma lead could not be determined on geological evidence alone because of the considerable thickness of Tertiary sediments and basalt. The limit of the basalt, as shown in Plate 2, in the area now occupied by the flooded mine workings, is based on the record of early boreholes, located as shown, along lines 2 to 7.

## 3. GRAVITY METHOD

The small amounts of alluvial tin present in deep leads cannot be detected by the gravity method, but where a density difference exists between the bedrock and the overburden, the course of the lead may be traced. Under favourable conditions, the position of the lead is indicated by a gravity 'low' because of the increased thickness of the lower density overburden over the lead.

The layout of the gravity traverses is shown in Plate 2. Twenty-three traverses with a total length of 149,500 feet were surveyed. In general, stations were spaced 100 feet apart along the traverses, but intervals of 50 feet were used over interesting areas, mainly near the Briseis mine, and intervals of 200 feet were used along the Derby-Branxholm Road (Traverse 2T).

Sharpe gravity meter No. 145 was used; its calibration factor was 0.10637 milligal per scale division. The base station chosen for the area was 6100 on Traverse 2D (Inset, Plate 3) and sub-bases were established at convenient locations throughout the area.

The gravity observations were corrected for instrumental drift, elevation, and latitude. The drift was controlled by reading the meter at least once per hour at a base or sub-base station. A density of 2.2 $g/cm^3$ was used for the elevation correction factor. The latitude correction was taken from the international formula (Nettleton, 1940) and amounted to 0.2955 milligal/mile, corresponding to latitude 41°12' of the base station.

The above-mentioned corrections are sufficient where the topography is reasonably flat, but in the southern part of the area there are topographical irregularities, which could have a considerable effect on the gravity readings and should therefore be taken into account.

The Sigmund Hammer method (Hammer, 1939) was used to calculate terrain effects. In this method, the area surrounding the gravity station is divided into zones by circles and radial lines and the terrain effects of individual zones are determined and summed to give the terrain correction. The effect of a zone is a function of its size, its distance, and the difference in elevation of the zone above or below the station.

Adequate topographical maps were not available for complete calculation of terrain corrections. Corrections were attempted only for an area to the north-west of the Briseis workings and only the first four (B,C,D,and E) of Hammer's zones could be used. These corrections should at least reduce the effects of topographical features within a radius of 1280 feet of the gravity station.

An alternative method of terrain correction was used along Traverse 2R. Here the terrain effects were mainly due to a topographical feature approximating to a two-dimensional body and were determined by means of a mechanical integrator.

The gravity observations after application of the above corrections gave the Bouguer anomaly values.

## 4. RESULTS AND INTERPRETATION

The Bouguer anomaly map of the whole area is presented in Plate 3 and the terrain-corrected anomaly map of the area north-west of the Briseis mine is shown in Plate 4. The gravity profiles on several traverses are shown in Plate 5 to illustrate the type of anomalies recorded and the rather large terrain corrections required in the neighbouthood of the mine workings.

The Bouguer anomaly map (Plate 3) shows a steep regional gravity gradient from north-west of the area to the south; this is attributed to deep-seated changes in the bedrock formations. In the survey area and areas to the north, it appears that regional gravity 'lows' coincide with outcrops of Devonian granite.

The interpretation of the more localised anomalies and detection of the presence of deep leads from the gravity results are made difficult by the geological conditions in the area. In the ideal case when the bedrock and overburden are uniform and there is an appreciable difference in their densities, the presence of a deep lead is revealed by a gravity 'low', the form and amplitude of which depend on the depth and shape of the old valley and the density contrast.

Basalt covers most of the survey area and attains a thickness of at least 200 feet in the vicinity of the Cascade lead. The topography of the Tertiary land surface on to which the basalt was extruded, is thought to be probably fairly flat or gently undulating. The junction between the basalt and the sediments is exposed only along the Cascade lead at Derby, but elsewhere the nature of the junction and hence the thickness of the basalt is unknown. The possible variations in the thickness and in the density of the basalt will lead to uncertainty in the interpretation. Uncertainty may also arise from variations in the density of the bedrock, which could be caused by weathering and changes in composition.

To illustrate the ambiguity in the interpretation of the gravity anomalies, four possible geological situations which all produce the same gravity 'low' are shown in Plate 6. These are:

(a) A deep lead under an even thickness of basalt.
(b) A hill composed of Tertiary clays and gravels in the pre-basalt landscape; this causes a gravity 'low' because it has the effect of reducing the thickness of the higher density basalt.
(c) Variation in thickness of weathering at the top of the basalt.
(d) Inter-basaltic weathering or presence of sediments between basalt layers. This situation is possible because the basalt is known to have occurred in at least three flows.

In attempting to interpret the broad type of gravity 'low' similar to that shown in Plate 6, it is not possible therefore to distinguish between the different possible causes of the anomaly, unless additional geological control is available. However, the small sharp gravity 'lows' which occur on some of the traverses, must arise from near-surface features and are almost certainly due to surface weathering in the basalt.

In order to examine the range of possible sections that fit the gravity data and the known outcrop geology, hypothetical sections were constructed for Traverses 2A and 2D (from 3000 to 11,000) and the theoretical gravity profiles were compared with the observed profiles (Plates 7 and 8). These traverses were chosen because it was possible to be fairly sure about the regional effect as both traverses go from bedrock to bedrock. The regional effect was subtracted from the observed profile and a comparison was made between the calculated and residual profiles. On Traverse 2A the gravity data for the portion 0 to 2000E were taken from the previous survey to the north (Sedmik, 1964).

Average densities were assigned to each group of strata. They were based on density determinations made on samples collected in the field, with the exception of weathered basalt and Tertiary sediments. The following were the densities used:

| | |
|---|---|
| Basalt | 2.8 $g/cm^3$ |
| Weathered basalt and clay | 2.0 $g/cm^3$ |
| Tertiary gravels, etc. | 2.0 $g/cm^3$ |
| Mathinna Group sandstone | 2.6 $g/cm^3$ |
| Devonian granite | 2.6 $g/cm^3$ |

Calculation of the gravity effects due to the assumed sections was performed with the aid of a mechanical integrator. Each section was progressively adjusted until a fair agreement was obtained between the residual and calculated profile.

Traverse 2A

In Section No. 1 (Plate 7), it is assumed that the thickness of the basalt is of the order of 100 feet in the western part of the traverse but increases to over 300 feet to the east and then decreases abruptly to account for the sharp fall in gravity at about 1000E. The actual profile here suggests a steeply dipping contact between the basalt and bedrock, due to either a fault or a pre-existing cliff face against which the basalt was deposited. In addition, it is necessary to include a weathered zone to account more fully for the steep gradient between 800E and 1200E.

From Section No. 1, it can be seen that the positive anomaly at 4000W cannot be explained by a hill in the bedrock and the steep gradients on the flanks of the anomaly are probably caused by surface features. Similarly the 'low' from 1600W to 2400W is probably due not to a thinning of the basalt as shown in Section No. 1 but rather to a weathered zone as shown in Section No. 2. Zones of weathering at the top of the basalt seem to be the most likely cause of other small sharp gravity 'lows' on the profile.

The bedrock below Traverse 2A comprises both Mathinna Group sandstone and Devonian granite. The contact, whose position at about 2000W is inferred from known geology, does not show up in the theoretical profile because the same density is assumed for both rock types. In Section No. 2, a greater thickness of basalt, of the order of 350 to 400 feet, is assumed and to compensate for this, about 350 feet of Tertiary sediments is required in the central part of the traverse. If the sediments below the basalt are denser than assumed, a still greater thickness will be necessary.

The two different geological sections considered give broadly the same calculated gravity profile. It appears likely that there is a bedrock valley filled with Tertiary sediments beneath the basalt between 2400Wand 7200W and it is possible that the ancient Ringarooma River flowed in this valley between these limits, but the exact position of the deepest part of the valley cannot be located, nor can the thickness of the basalt and sediments be predicted.

Traverse 2D

Three geological sections were drawn up and progressively adjusted until a reasonable fit was obtained between the calculated and observed profiles. (Plate 8)

From the three sections, it appears that the anomalies at 7200 to 8200 and 6100 to 7000 are more likely to be due to surface weathering, as in Section No. 1, than to depressions in bedrock, as in Sections Nos. 2 and 3. The basalt appears to be at least 350 feet thick, and is probably thicker if there is an appreciable thickness of Tertiary sediments below the basalt. It will be seen that Section No. 1 gives the best agreement but this does not mean that it is necessarily the correct solution.

The details of the structure causing the 1½-milligal gravity 'low' between 8200 and 11,000 cannot be defined with certainty but the sections show three possibilities, two of which imply a bedrock depression below the anomaly.

## Deep Leads

In the discussion of the profile on Traverse 2A, attention was drawn to the broad gravity 'low' between 2400W and 7200W, which suggests a valley in the bedrock filled with Tertiary sediments beneath the basalt. From the Bouguer anomaly map (Plate 3) this gravity 'low' appears to continue in a general southerly direction to about 3500 on Traverse 2C. It then swings to the south-south-west to cross Traverse 2F near the intersection with Traverse 2J and then continues through about 3200 on Traverse 2K in the direction of the Briseis workings. From the terrain-corrected map (Plate 4), the 'low' appears to approach the workings a short distance east of Traverse 2P. This gravity feature may represent the course of the ancient Ringarooma River. The possibility that it is due to an inter-basaltic erosion feature is considered unlikely as there is no evidence on the cliff face at Derby, where the whole basalt section is exposed, of erosion sufficient to cause such an anomaly.

North-west of the Briseis workings, the gravity contours (Plate 4) reveal a 'low' that can be traced across Traverses 2J, 2Y, 2S, and 2Z at 4400, 350S, 400S, and 350S respectively. This anomaly is possibly the manifestation of a lead at depth. A weaker gravity 'low' appears on Traverses 2Z, 2S, and 2Y following the trend of Joey's Creek, but its significance is very doubtful. It could be caused by a lead or by thinning of the basalt along the creek.

A pronounced gravity 'low' occurs on Traverse 2D between 8200 and 11,000. Part of the 1½-milligal anomaly is certainly due to the terrain effects of the steep gully to the east but even after application of terrain corrections, the anomaly would still be of the order of 1 milligal. Although the interpretation is subject to uncertainty as illustrated by the sections in Plate 7, the anomaly may be due to a depression in the bedrock and therefore represents an area of interest in the search for deep leads.

From the work of Nye (1925) the Main Creek lead, another of the previously worked tributary leads, would be expected to enter the survey area from the south-east. Traverse 2D should cross the presumed continuation of this lead at about 6400. The interpretation of the profile along Traverse 2D (Plate 8) suggests a large thickness of basalt at this locality, but there is no firm evidence of the presence of a lead.

## 5. CONCLUSIONS AND RECOMMENDATIONS

The interpretation of the gravity survey is subject to uncertainty, mainly owing to the unknown and probably variable thickness of basalt covering most of the area and to the large terrain effects in the southern part of the area, which could not be determined accurately. However, it has been possible to trace a few gravity 'lows' that may represent the courses of deep leads. On this basis it would appear that the Ringarooma lead meets the Cascade lead immediately west of Briseis workings and then continues through the area in a general northerly direction (Plate 9). A tributary lead appears to enter the Ringarooma lead from the north-west near Traverse 2S. The position of the Ringarooma lead upstream from Traverse 2M is that inferred by Nye (1925) and is indicated to show the continuity with the lead positions deduced from the gravity work.

In any further investigations of the area, the next stage should consist of drilling to test the validity of this gravity interpretation. Drilling of vertical holes for the purpose of testing the gravity 'lows' is recommended in three localities (Plate 3):

(1) To test the north-trending 'low' that may represent the main Ringarooma deep lead, drill holes Nos. 1 and 2 between Traverses 2R and 2P and drill hole No. 3 at 3100 on Traverse 2S.

(2) To test the 'lows' to the north-west of the Briseis mine, drill hole No. 4 at 300N on Traverse 2Z and drill hole No. 5 at 400S on Traverse 2S.

(3) To test the 'low' between 8200 and 11,000 on Traverse 2D, drill hole No. 6 at 9300 and drill hole No. 7 at 9600.

In addition to testing the most interesting features of the gravity survey, the drilling should provide a basis for the more accurate interpretation of the gravity results in the remainder of the area.

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| | | |
|---|---|---|
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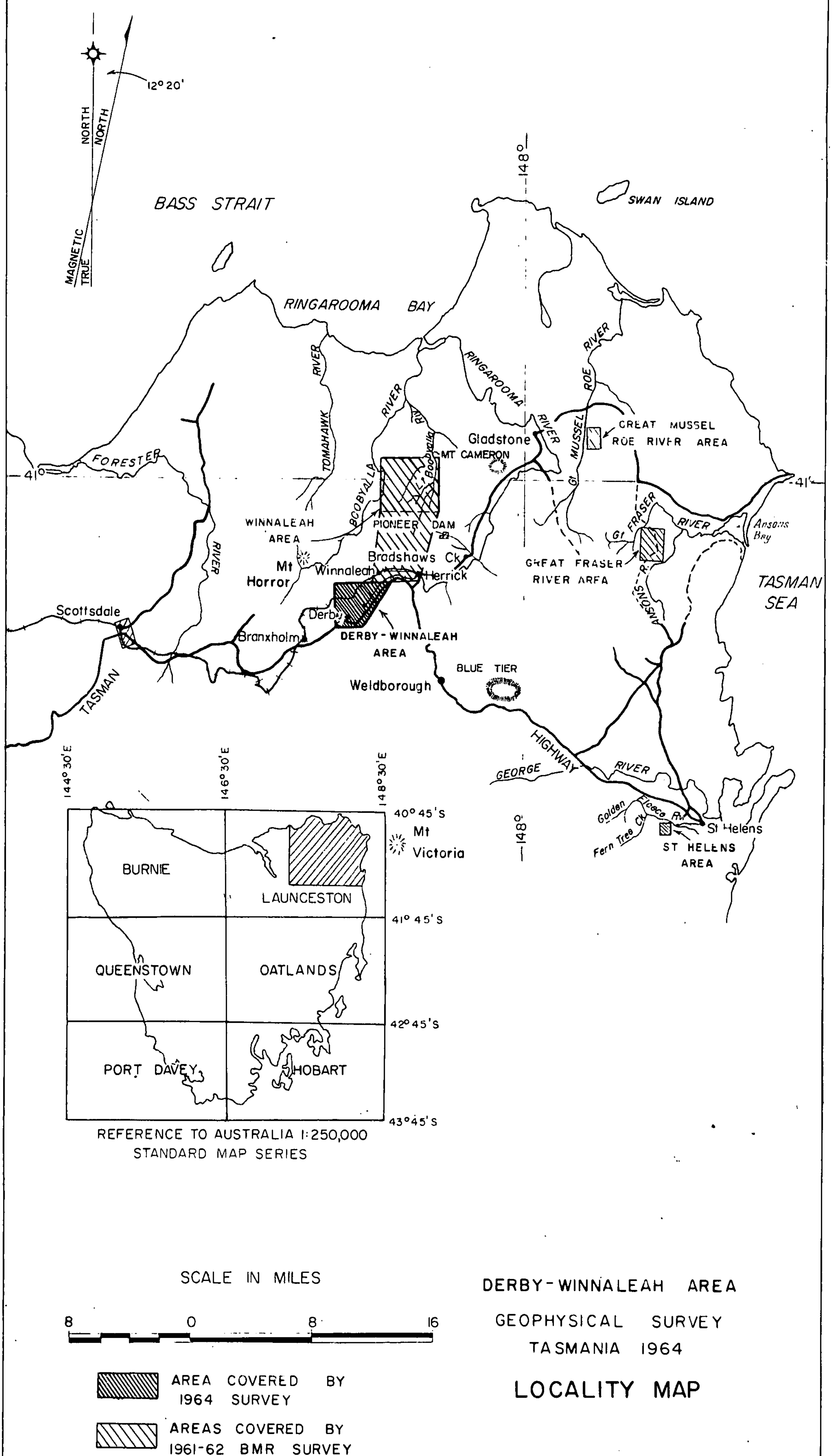
PLATE I




DERBY - WINNALEAH AREA

GEOPHYSICAL SURVEY

TASMANIA 1964

## LOCALITY MAP

K55/B7-25-2

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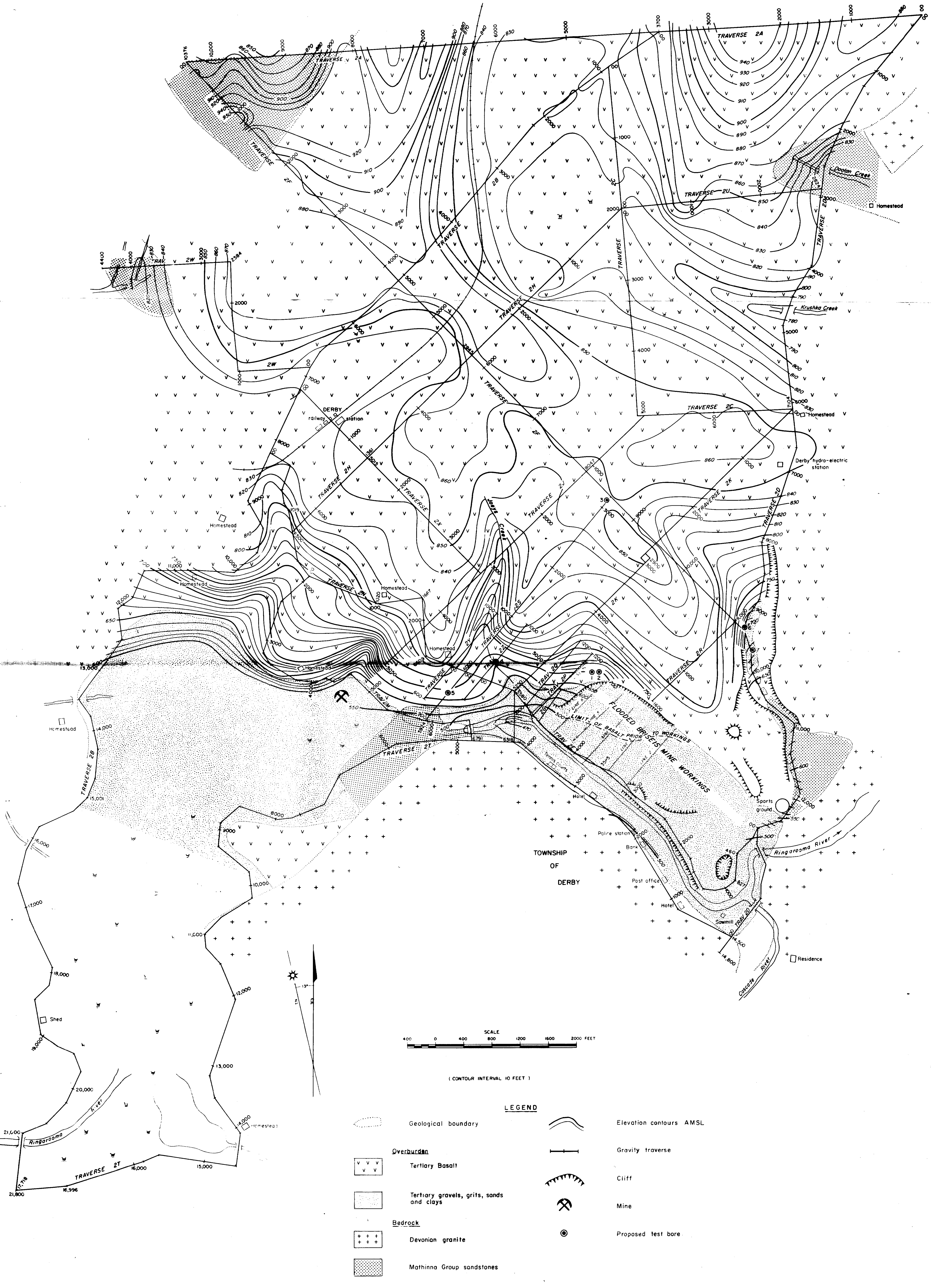
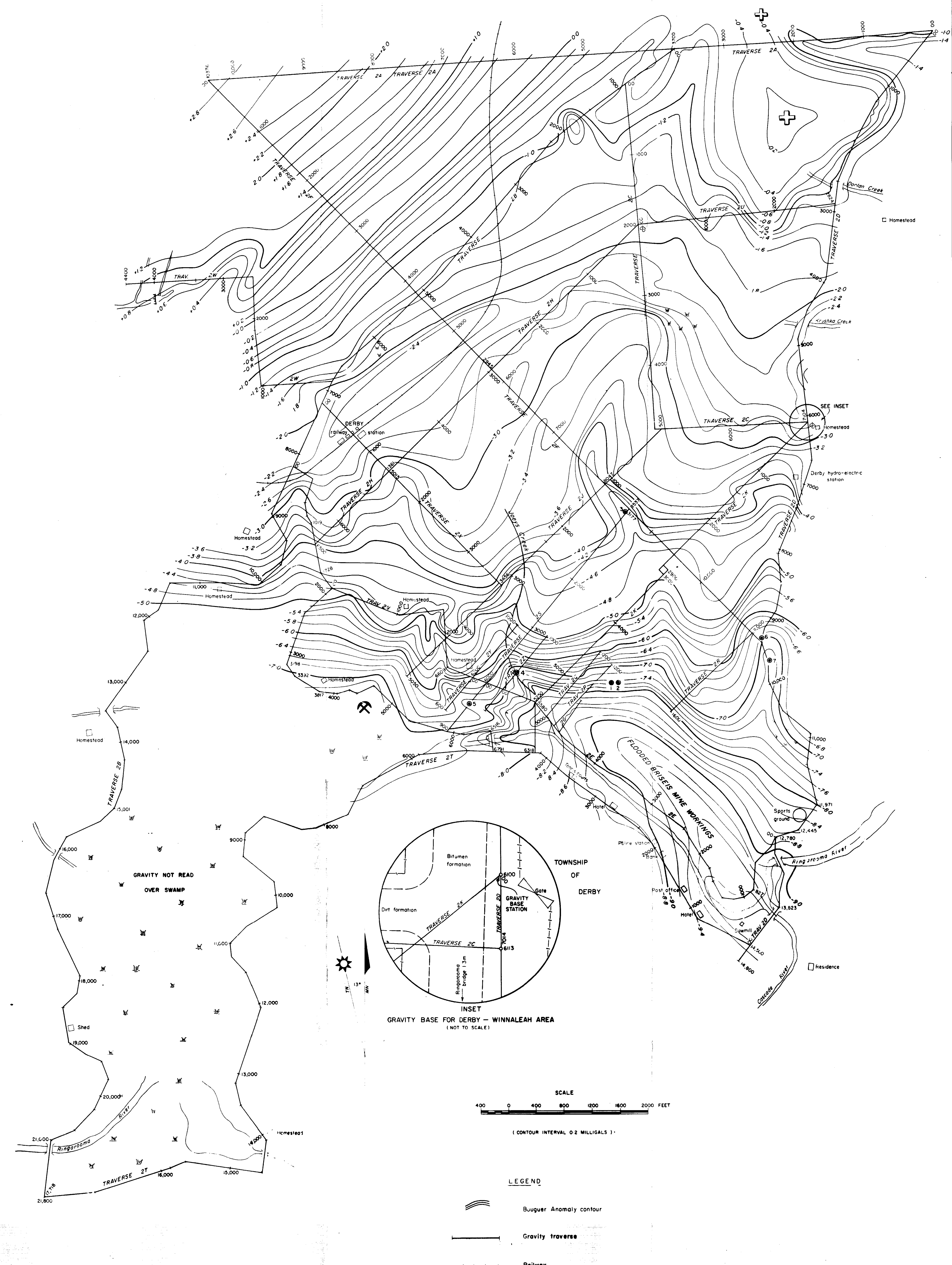
PLATE 2

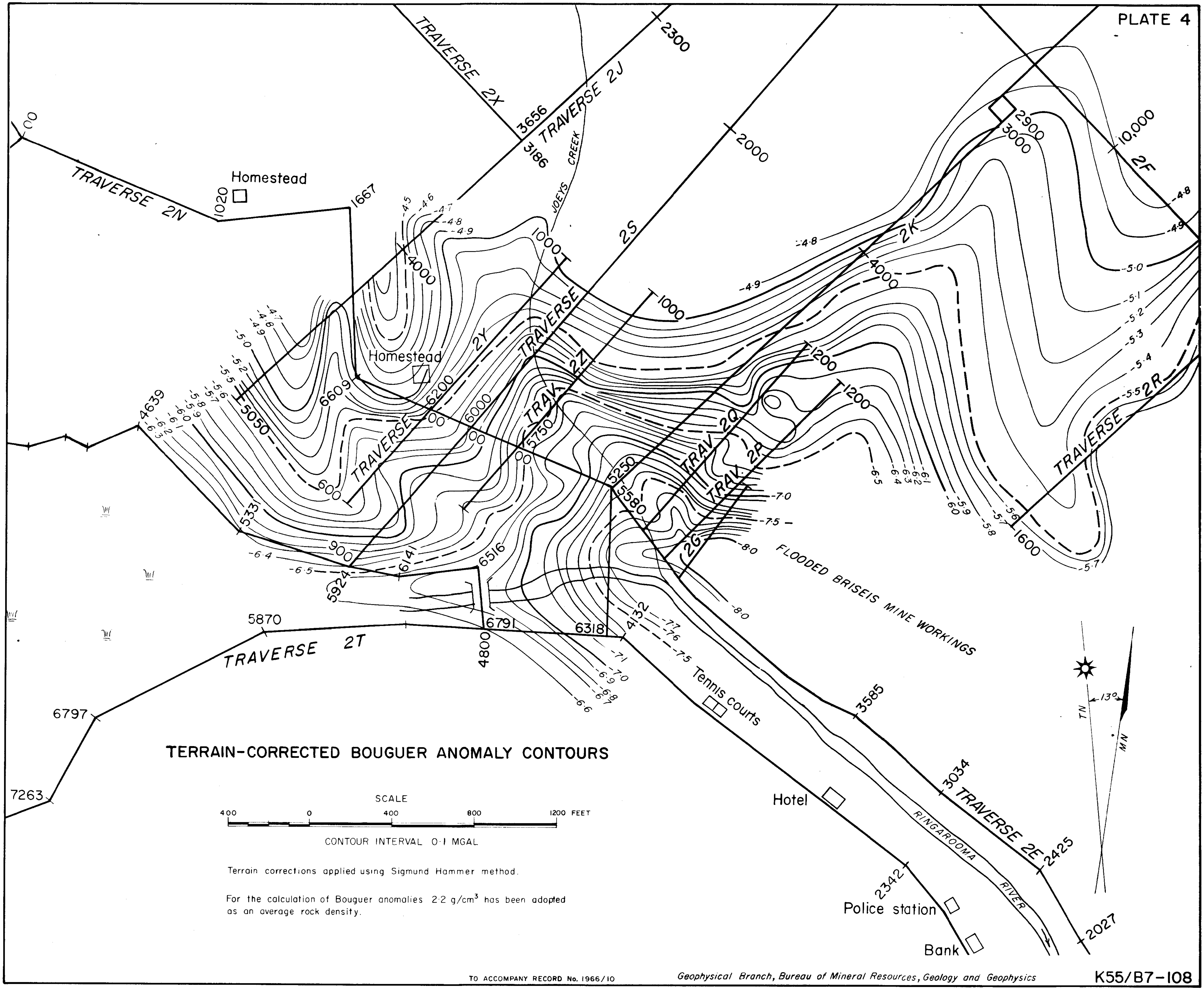



## TOPOGRAPHY, GEOLOGY AND TRAVERSE LAYOUT

PLATE 3




BOUGUER ANOMALY CONTOURS




## TERRAIN-CORRECTED BOUGUER ANOMALY CONTOURS

CONTOUR INTERVAL 0·1 MGAL

Terrain corrections applied using Sigmund Hammer method.

For the calculation of Bouguer anomalies 2·2 g/cm³ has been adopted as an average rock density.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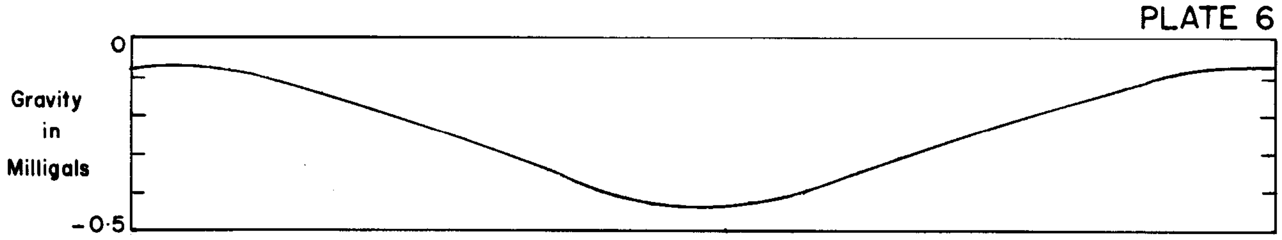
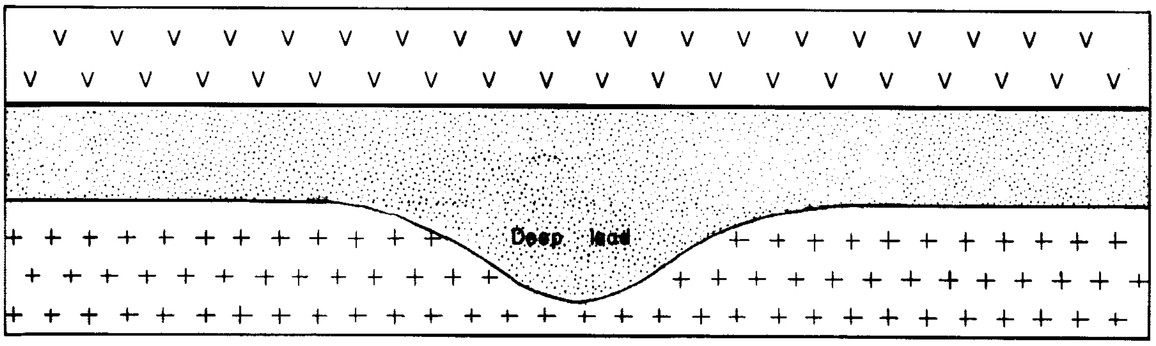
K55/B7-114

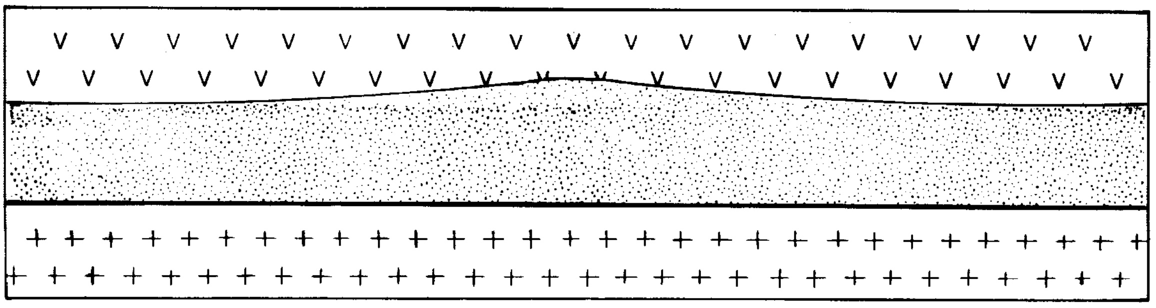
PLATE 6



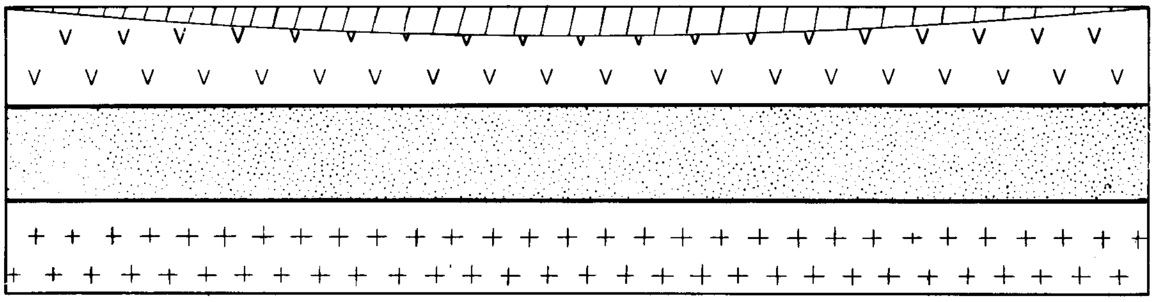

All geological sections A – D produce the gravity profile shown above



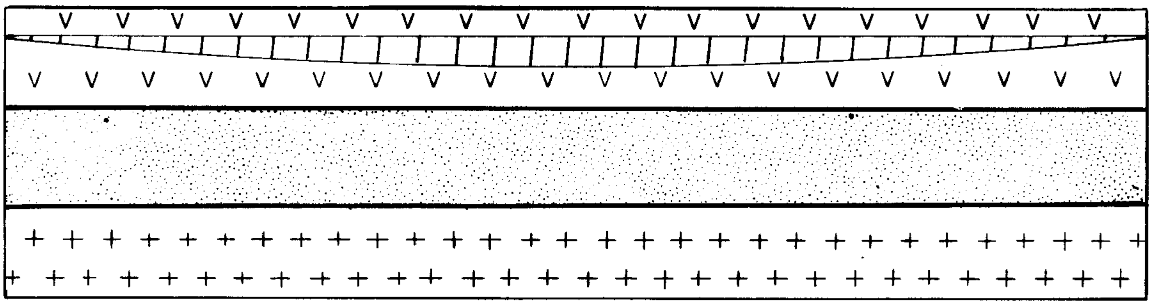

A — deep lead



B — Hill in pre-basalt landscape



C — Variations in surface weathering of basalt



D — Inter-basaltic weathering

Basalt Density 2·8 g/cm³ — Drift Density 2·0 g/cm³ — Granite Density 2·6 g/cm³ — Clay (weathered basalt) Density 2·0 g/cm³

Horizontal and Vertical Scale 1" = 400ft

## SOME POSSIBLE CAUSES OF NEGATIVE GRAVITY ANOMALIES IN THE DERBY – WINNALEAH AREA

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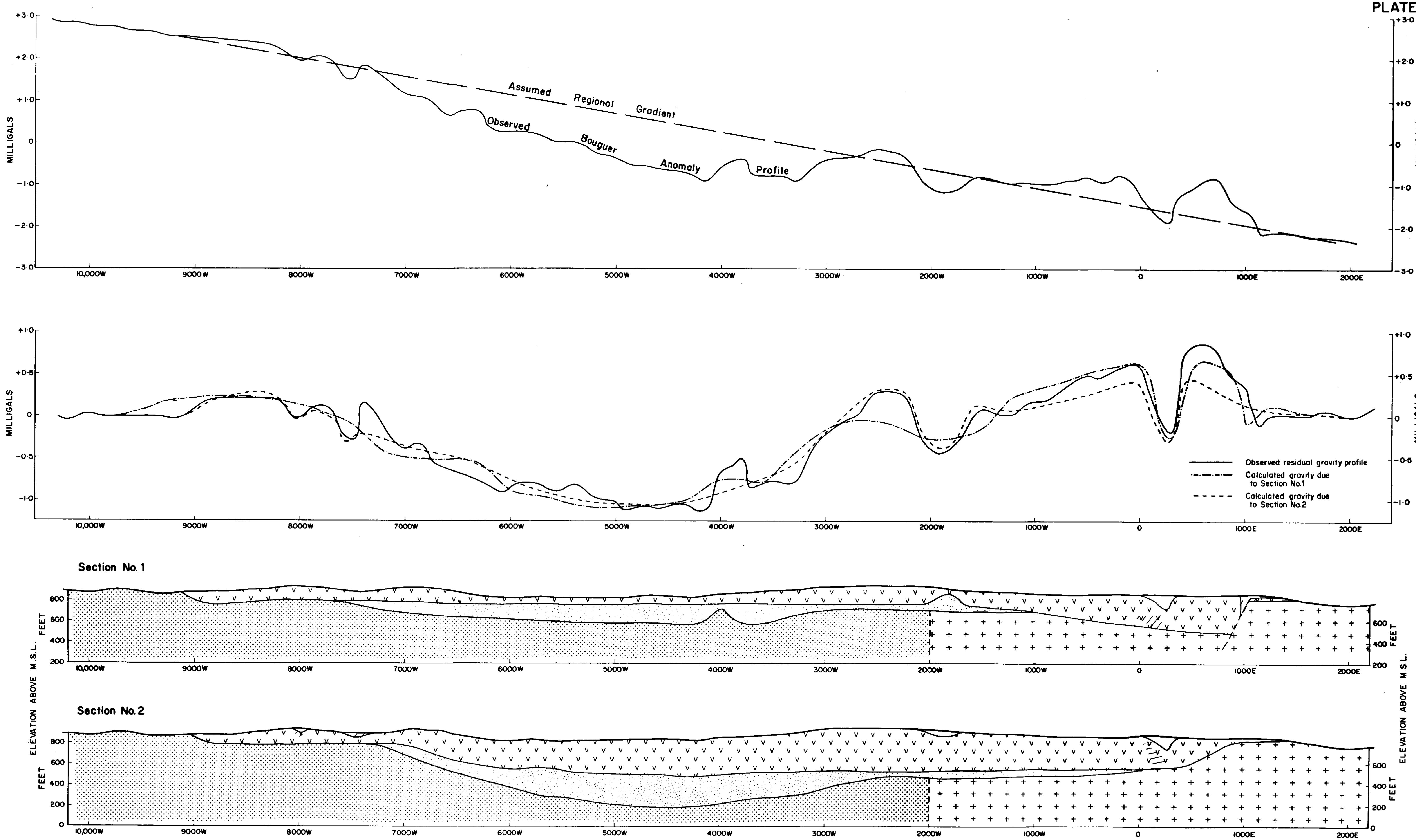
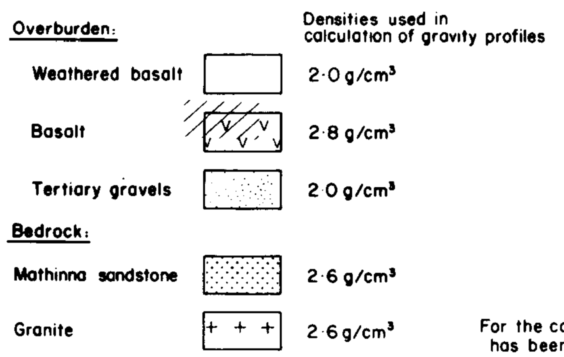
PLATE 7




LEGEND




For the calculation of Bouguer anomalies 2·2 g/cm³ has been adopted as an average rock density


# TRAVERSE 2A

COMPARISON OF RESIDUAL BOUGUER ANOMALIES AND BOUGUER ANOMALIES CALCULATED FROM THEORETICAL GEOLOGICAL CROSS-SECTIONS

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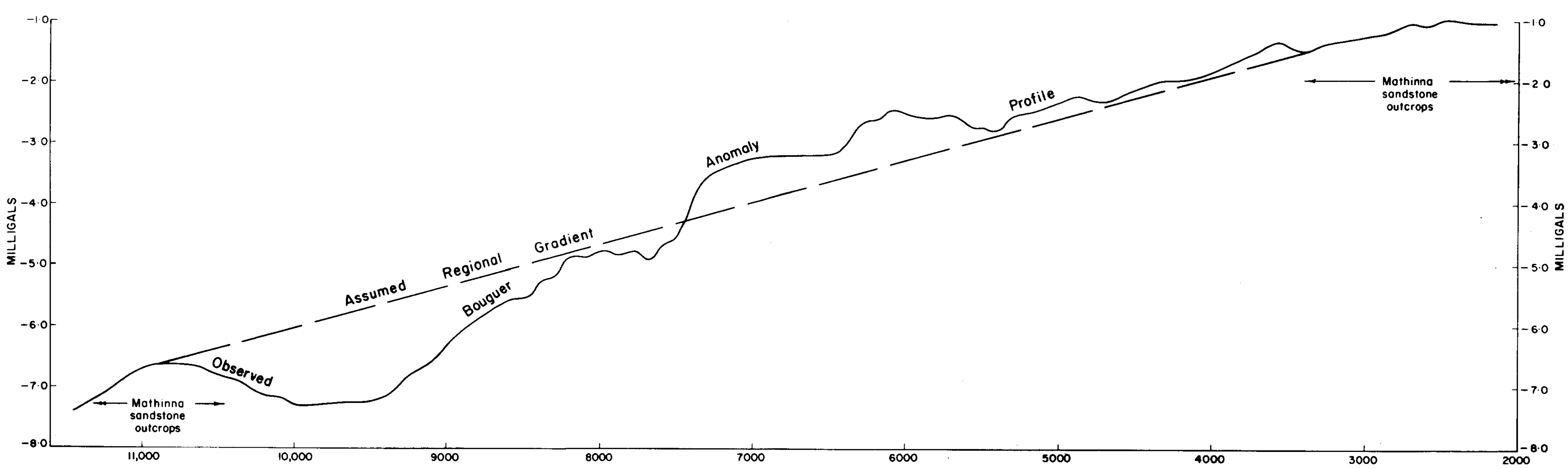
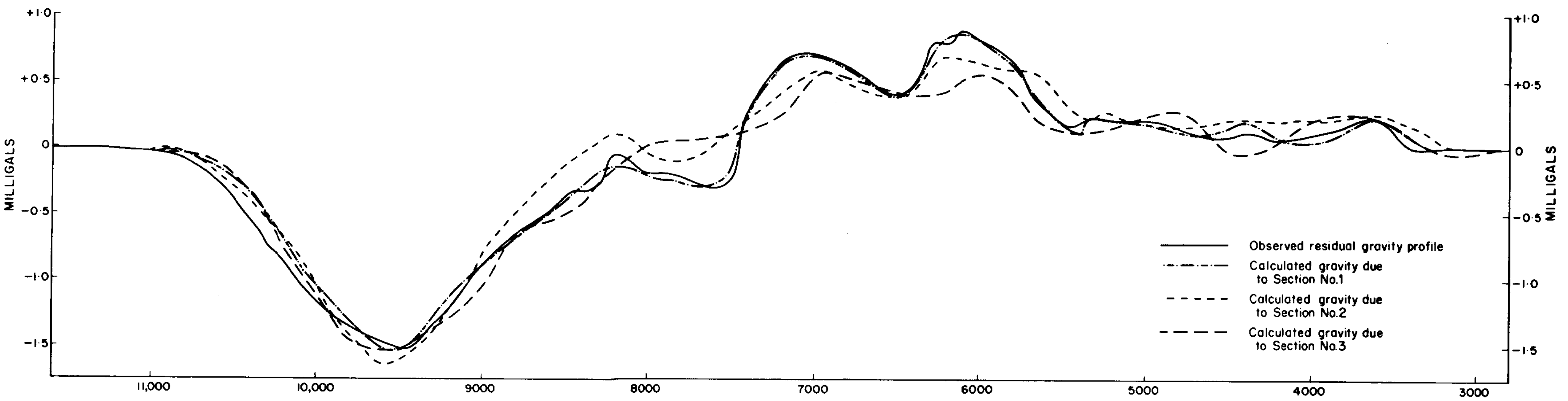
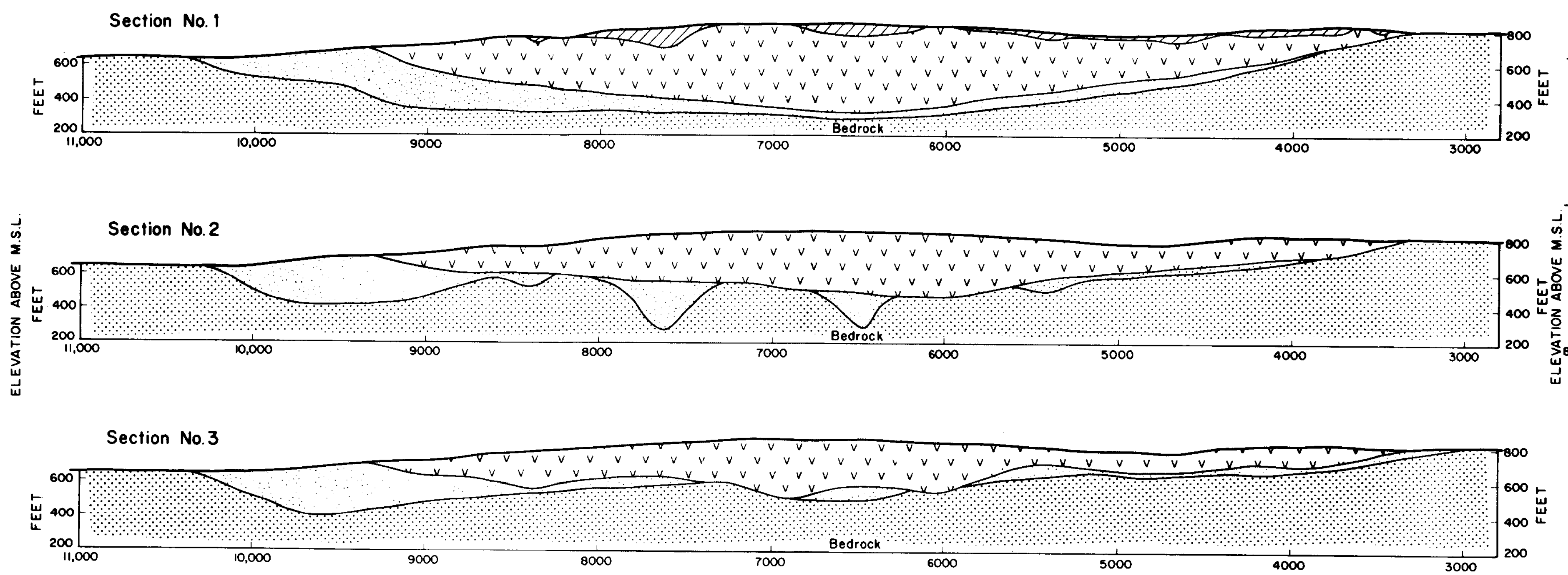
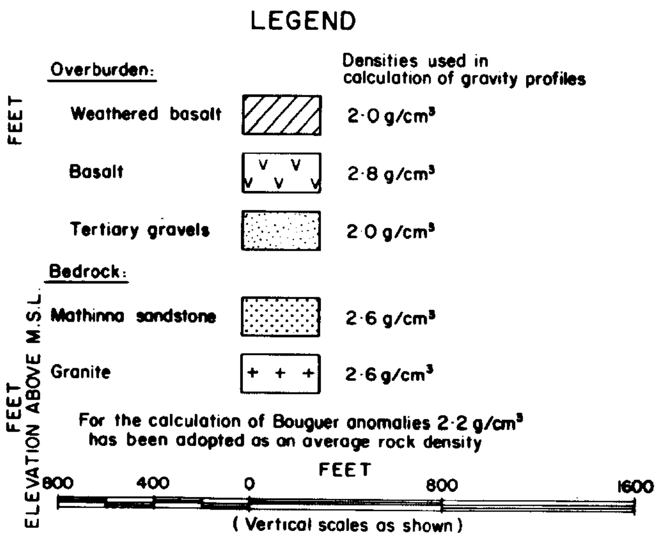


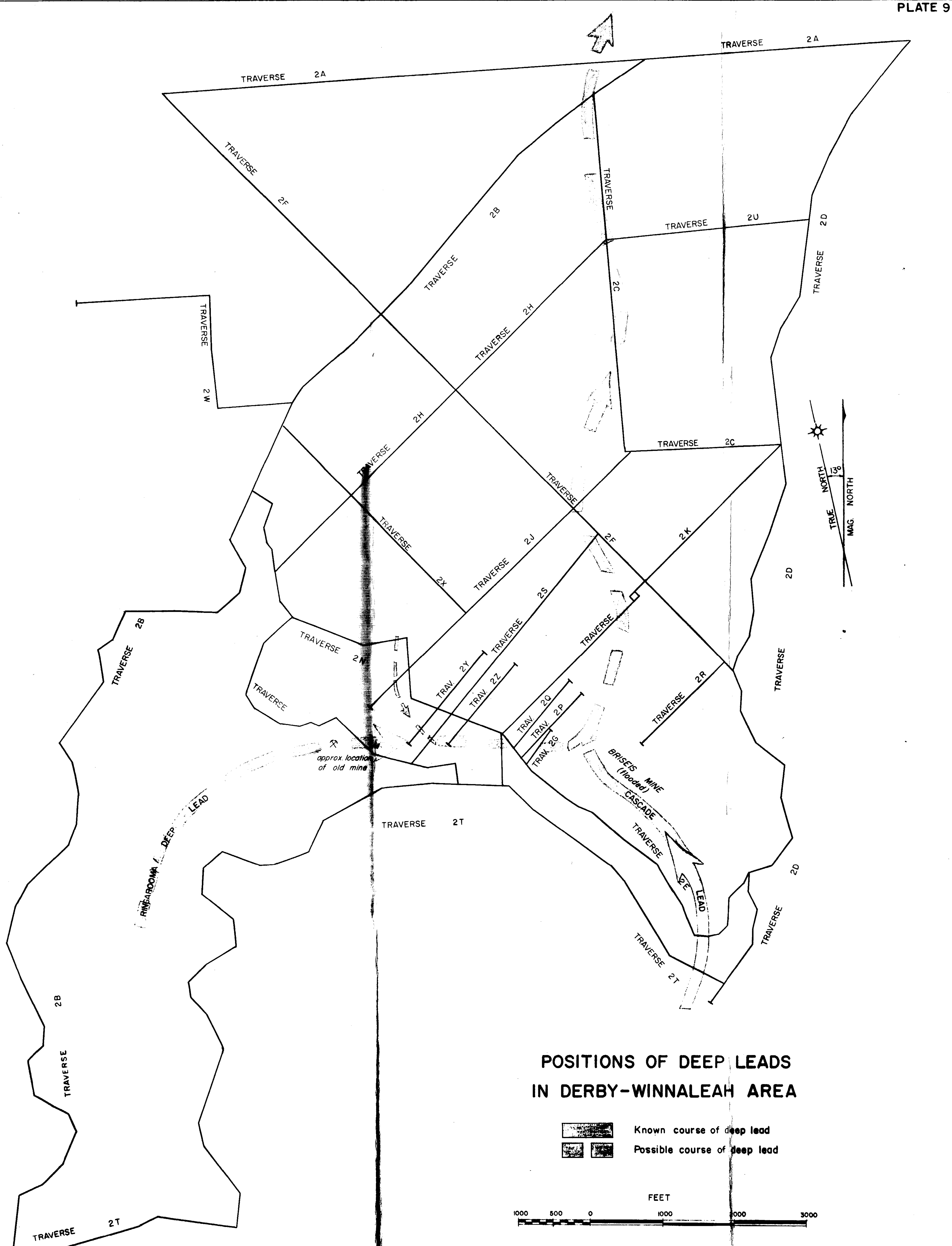

# TRAVERSE 2D

## COMPARISON OF RESIDUAL BOUGUER ANOMALIES AND BOUGUER ANOMALIES CALCULATED FROM THEORETICAL GEOLOGICAL CROSS-SECTIONS



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