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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1963/113

YITHAN GRAVITY SURVEY, NEAR ARDLETHAN, NSW 1959

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CONTENTS

ILLUSTRATIONS

SUMMARY

A detailed gravity survey was made in three areas near the former village of Yithan, near Ardlethan, NSW, where Prospectors Pty Ltd held several mining leases and was actively engaged in alluvial tin mining. Gravity values for 1024 gravity stations were computed using standard methods. Survey results are presented mainly in the form of Bouguer-anomaly contour plans.

The gravity method was found to be suitable for prospecting for deep leads under the local geological conditions and was used to search for possible deep leads north of the Yithan group of mines.

A possible deep-lead system was discovered north of Yithan. It could be of economic interest because its source is an area where rich lode tin deposits are known to exist.

1. INTRODUCTION

The geophysical survey described in this Record was made by the Bureau of Mineral Resources, Geology and Geophysics, as a result of an application by Prospectors Pty Ltd supported by the New South Wales Department of Mines.

Prospectors Pty Ltd was actively engaged in mining alluvial tin ore from a deep lead and it held several leases near the former village of Yithan, three miles north-west of Ardlethan, NSW. Ardlethan is about 340 miles west of Sydney on the Temora-Griffith railway line.

Previous geophysical surveys (Urquhart, 1956; O'Connor, 1958 and 1959) have shown that the seismic refraction method can be successfully applied to prospecting for tin-bearing leads in this area. The purpose of the gravity survey described in this Record was firstly, to test the suitability of the gravity method by applying it to an area that had previously been surveyed by the seismic method, and secondly, to make reconnaissance surveys over other areas in the district where tin-bearing leads may be present.

The gravity survey was made during March and April 1959 by geophysicist E.C.E. Sedmik and a field assistant. Pegging and levelling of the traverses was done by A.A.C. Mason of Prospectors Pty Ltd whose assistance in providing the party with geological and drilling information is gratefully acknowledged.

2. GEOLOGY

The geology of the Ardlethan tinfield has been described by Godfrey (1915), Harper (1919), and more recently by Raggatt (1939, 1950a, and 1950b) and Garretty (1953).

The tin-bearing area is west of the township of Ardlethan and is on the eastern side of a line of low hills. The hills consist mainly of granite as undenuded remnants of a biotite-granite batholith which intruded Silurian sediments. The sediments consist mainly of quartzite, micaceous sandstone, slate, and breccia, and have a prevailing westerly dip. Sediments close to the granite contact have been altered to mica schist.

The granite belt is about 12 miles long and five miles wide. In places, the granite has been extensively altered along major joint planes to quartz-tourmaline rock and greisen. These altered zones contain cassiterite, often in high concentrations. Previous mining has consisted largely of extracting, by small workings, the portions richest in cassiterite, but these operations have practically ceased. The working of the primary deposits by open-cut on a large scale is now in its developmental stage.

The workings of the whole area can be divided into four groups :

(a) The Bygoo group at the northern end of the field,

(b) The Yithan group, including the Carpathia, White Crystal, and Wild Cherry mines. This group has been the main producer, and will now be developed on a large scale,

(c) The Taylors Hill group, west of Yithan, and

(d) The Bald Hill group, at the southern end of the field.

The total production has been about 4000 tons of cassiterite.

The outcrop of the granite is bordered by almost-flat alluvial deposits, which conceal the ancient drainage channels. Where these channels contain material derived from the weathering of mineralised portions of the granite, they may be sufficiently rich in cassiterite to be mined profitably. One such channel, between the Carpathia and Southern Cross hillsides, was mined to shallow depth in the early days of the field. The possibility of alluvial mining has been investigated by North Broken Hill Ltd and Mount Isa Mines Ltd. At the request of North Broken Hill Ltd a geophysical survey was made by the Bureau during 1948 (Urquhart, 1956) and indicated the possibility of a concealed channel east of the Bygoo mines. The results of this survey have not been tested. In 1951 Mount Isa Mines Ltd tested the White Crystal workings by drilling and shaft sinking. This testing showed that previous alluvial mining had terminated on a false bottom, and that a previously-untested channel was present at a depth of about 100 to 160 ft. Mount Isa Mines Ltd relinquished its interest in the area in 1953, but the channel has since been profitably mined by Prospectors Pty Ltd.

A typical cross-section through the lead is as follows :

top layer of alluvium; 30 to 40 ft thick, containing fine cassiterite, false bottom of hard ferruginous clay,

second layer of red clay with a few sand lenses; about 90 ft thick, containing no cassiterite,

wash consisting of granite and slate detritus embedded in red clay; a few feet thick, and containing a high percentage of coarse cassiterite, bedrock (granite or Palaeozoic sediments).

The top layer was the source of the alluvial tin ore mined in the early days of the field. Present mining is confined to the wash overlaying the bedrock.

3. APPLICABILITY OF THE GRAVITY METHOD

The density of unconsolidated surface material is, in general, less than that of massive rock. It would be expected, therefore, that the gravitational field over an area would be influenced by any lack of uniformity in the thickness of the surface cover, and would show negative anomalies over parts where this cover was unusually thick. This provides a basis for the use of the gravity method in prospecting for buried channels.

This possibility was recognised as early as 1930, when the Imperial Geophysical Experimental Survey made a short gravity survey in the Gulgong goldfield, NSW (Broughton Edge and Laby, 1931). However, the gravity-measuring equipment available at that time was very slow and cumbersone in operation, and extensive surveys would have been uneconomic. The first tests over deep leads in Australia using modern equipment were made by the Bureau of Mineral Resources near Kalgoorlie in 1948 (Urquhart, 1956). The seismic refraction method was the main one used on the survey and it located several channels in the bedrock. Gravity measurements were made over the seismic traverses and indications of the same channels were obtained. However, the results of this work have not been tested. As the gravity method, using modern gravity meters, is much quicker and cheaper than the seismic method, Urquhart (op. cit.) suggested that for deep lead investigations, the gravity method should be used for reconnaissance, and that the use of the seismic method be restricted to areas indicated as favourable by the gravity survey.

4. TECHNICAL DETAILS

The gravity survey at Yithan involved three parts:

(a) Testing the applicability of the method. This was done by means of a detailed survey over an area (shown as area No.1 in Plate 2) where a seismic survey had previously been made, and the position of the lead had been checked by mining operations,

(b) Investigating an area (shown as area No.2 in Plate 2) south of the known lead, in which the company had sunk a shaft (No.6) without success,

(c) Prospecting for possible leads north of the Yithan group of mines. This involved a number of reconnaissance traverses, and a detailed survey of a selected area (area No.3 in Plate 2).

The readings were taken on an Atlas gravity meter, with a scale value of 0.1209 mgal/dial-division. Drift was controlled by readings on a sub-base station, repeated every half hour. Checks on the overall accuracy of the observations were made by repeating the readings on a few stations on each traverse. Differences of more than 0.04 mgal between readings at a particular station were considered unacceptable and in such cases the whole group of readings involved was repeated. Sub-base stations were connected using the standard looping method. Station 500E on Traverse C, near shaft No.1 was used as the main base for the survey and as the datum for levels. Gravity-meter readings were made at a total of 1024 stations.

A latitude correction of 1.217 mgal/mile with reference to the base station was made to all readings. For this purpose, the latitude of the base station was taken as 34°19'S. Owing to the flatness of the topography, terrain corrections were not required.

The most convenient method of presenting the results is as contour maps of Bouguer anomaly at a suitable datum level. For this purpose, a correction must be applied to each reading, taking account of the difference in elevation and the density of the material between the station and the datum level. The choice of a suitable density value for this purpose is difficult. For an exact reduction, the density distribution of the material between each station and the datum level must be known. However, this information is generally unavailable and the density value must be estimated. For studies on a regional scale, a density value of 2.2 g/cm^3 is generally used. In detailed studies of small areas, a more appropriate value may be desirable. In the present survey, the matter was not of great importance as the differences in elevation are small; the survey was aimed at discovering the position of the deep lead, without attempting to estimate the actual depth to it. In the Yithan survey, the results have been reduced to a level 48 ft below the level of the survey datum, as this is approximately the elevation of the lowest point of the ground surface.

The effects due to varying thickness of overburden are superimposed on regional effects; it is desirable that some process be available for separating them. This matter has received a good deal of attention, and a considerable literature exists. The bases of the various methods have been reviewed by Nettleton (1954), who gives references to the original papers.

If the regional effects are of a simple type (such as a uniform gradient in one direction), they can be easily subtracted from individual profiles and the residuals plotted. Other more-refined graphical methods are possible. However, if the regional effects that it is desired to remove are of complicated type, such operations involved a considerable subjective element.

5. RESULTS

The results are presented in Plates 2 to 5. Results over the various areas surveyed are discussed separately.

Regional field

Plate 2 is a composite contour plan of the Yithan area showing contours of Bouguer anomaly. In order to avoid complicating the plan with small-scale effects, results at stations 500 ft apart along the traverses have been used. A density of 2.2 g/cm^3 has been used for the reductions. To obtain a gravity picture of the whole area, contours have been interpolated through areas in which control by observations was not available. In this interpolation, account has been taken of information obtained by mining development and seismic surveys. Such interpolated contours are shown by broken lines.

The gravity contours show a well-marked regional effect, the Bouguer-anomaly values decreasing to the north and west. To obtain full information on the regional effect more extensive coverage by gravity observations would be required.

The Yithan deep lead appears as a well-defined gravity minimum. Another minimum begins about half a mile north of Yithan, and extends north for about a mile. This may indicate a channel draining the area north of Yithan. Gravity minima between F2500W and F3000W and near A5500W may indicate other channels, and are worthy of further investigation. As this area was surveyed at reconnaissance scale only, no detailed conclusions can be drawn on the basis of the results of the present survey.

Area No.1. The detailed survey over area No.1 was made to compare the gravity results with the results of the seismic survey. The results have been included in the report on the seismic survey and the comparison discussed by O'Connor (1959). It is shown that the results using the two methods of survey are closely similar.

Area No.2. The results of the detailed survey over area No.2 are presented in Plate 3, as a Bouguer-anomaly contour plan.

A density value of 2.0 g/cm^3 has been used for the Bouguer corrections.

The detailed survey over area No.2 was made at the request of the operating company, whose shaft No.6 had failed to intersect the lead. The results show a well-defined gravity minimum coinciding in position with the lead as known from workings. This minimum can be traced for about 400 ft south of the worked portion of the lead but near shaft No.6 the results become less definite; Traverses 820S and 960S in particular lack the gravity 'lows' of the adjacent traverses to the north. However, it is considered that the lead passes about 50 ft west of shaft No.6 and continues with a general south-easterly course. Another gravity minimum west of the main channel may indicate a tributary lead, which probably joins the main lead a little south of shaft No.6. However, the cause of this gravity minimum is uncertain, as neither the gravity results nor the surface geology show any indication of a prolongation past 500W on Traverse 710S. For various reasons, Prospectors Pty Ltd decided not to continue its operations south of shaft No.6; therefore the interpretation of the results has not been tested.

Area No.3. The results of the detailed survey in area No.3 are shown as contours of Bouguer anomaly in Plate 4. A density value of 1.8 g/cm^3 has been used for the Bouguer corrections.

The results are consistent with the presence of a lead coming from the south-west and passing through D300W, C1800E, and B2500E, with a tributary from the north passing through BB400E, A50W, B200E, and C500E.

As a partial check on the interpretation of the gravity survey, a seismic refraction survey was made along portions of Traverse A (O'Connor, 1959). The results are shown in Plate 5, together with the gravity profile. The seismic results indicate that the bedrock depression from 2500E to 3000E is deeper and more important than that centred near 00. This is not apparent from the gravity profile. The high observed bedrock velocities indicate that the bedrock in this area is granite.

6. CONCLUSIONS AND RECOMMENDATIONS

General

In general, it can be concluded that the gravity method can be successfully used in prospecting for tin-bearing leads on this field.

Area No.2

The results of the gravity survey in Area No.2, as shown in Plates 2 and 3, indicate that:

(a) The course of the deep lead continues in a south-easterly direction and passes west of shaft No.6,

(b) A tributary from the west may join the main lead near shaft No.6.

The following recommendations are made for testing area No.2:

(a) Sink a new shaft at 550S, 775E in the area north of shaft No.6 where the position of the deep lead is well-defined by the gravity results,

(b) Crosscut from the bottom of shaft No.6 in a westerly direction to intercept the alluvial gutter, and

(c) More-detailed gravity work should be done south of Traverse 960 if the extension of mining operations south of shaft No.6 is contemplated.

Area No.3

The results of the gravity survey in area No.3, as shown in Plates 4 and 5, indicate that:

(a) There is probably a deep lead which passes through D300W, C1800E, and B2500E and has a north-easterly course. From the drilling information obtained at boreline No.4 it can be inferred that at B2500E the depth from the surface to the bedrock will exceed 175 ft. Boreline No.4 should be continued beyond NA 9 for about 250 ft with boreholes spaced not more than 100 feet apart in a south-easterly direction to establish the position of the deep lead near B2500E and to check whether the tin content is high enough for profitable mining,

(b) There is a tributary lead from the north.

The following lines of boreholes are recommended for further investigation of the deep lead system:

A100W to A100E

B00 to B300E

D500W to D00

Positions for future shafts should be determined by short seismic traverses.

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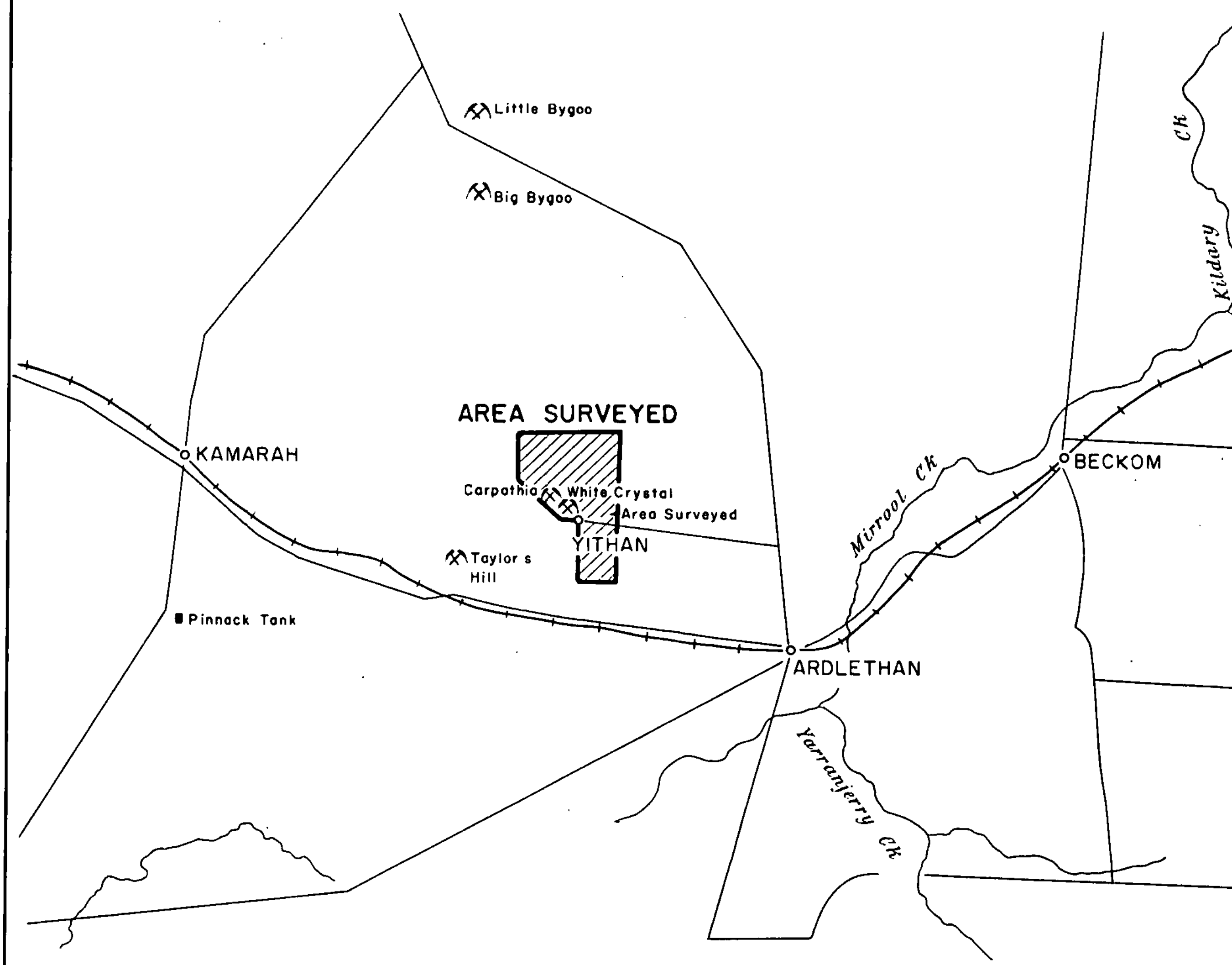
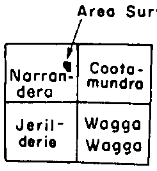
PLATE I



GRAVITY SURVEY AT YITHAN, NEAR ARDLETHAN, NSW 1959

LOCALITY MAP

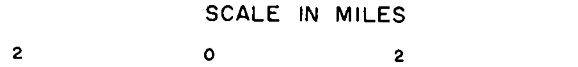


REFERENCE TO AUSTRALIA STANDARD MAP SERIES

LEGEND

- Lode tin mine
- Road
- Railway

SCALE IN MILES



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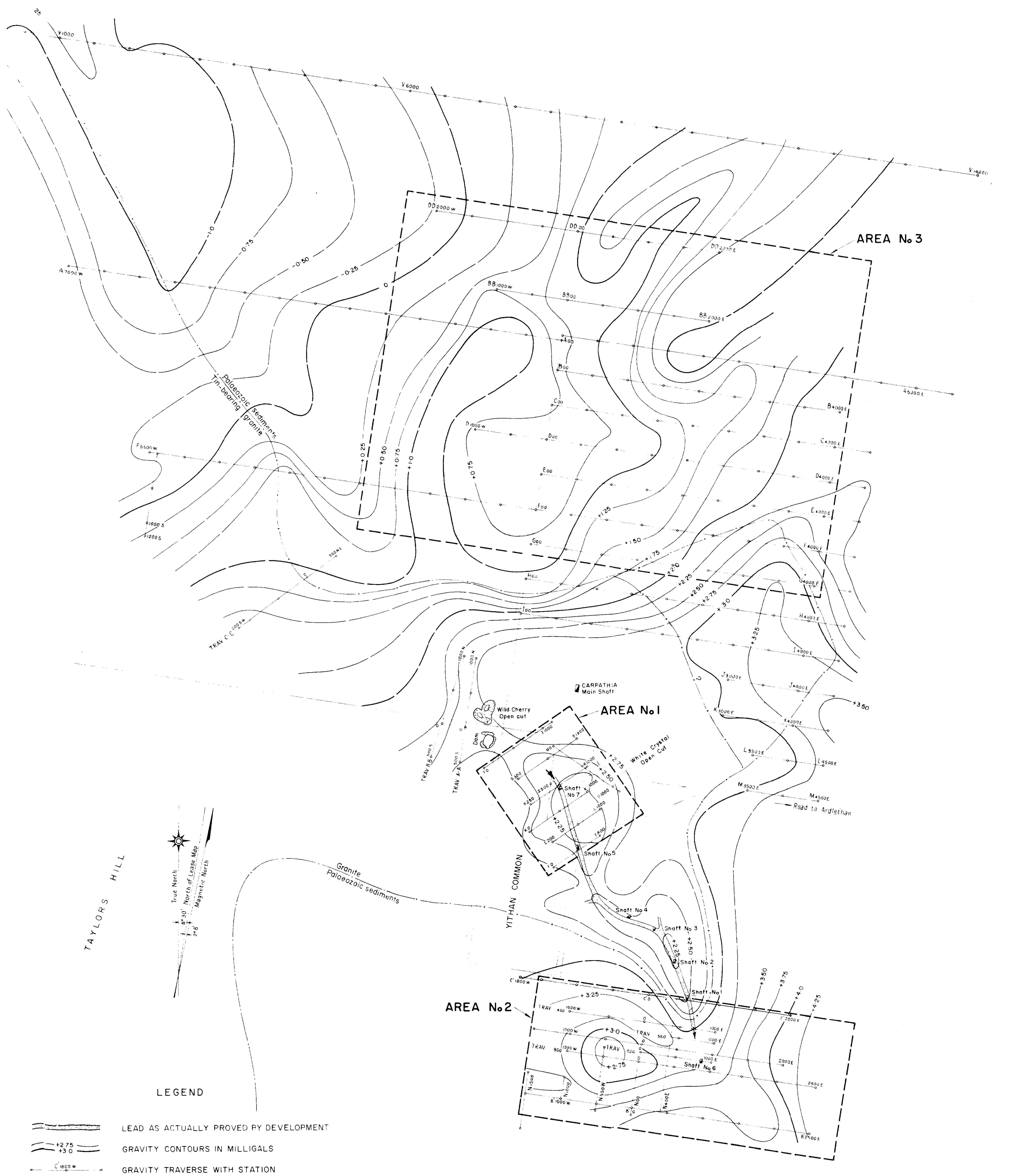

LEGEND

LEAD AS ACTUALLY PROVED BY DEVELOPMENT

GRAVITY CONTOURS IN MILLIGALS

GRAVITY TRAVERSE WITH STATION

AREA OF DETAILED GRAVITY SURVEY

BOUNDARY BETWEEN GRANITE AND PALAEOZOIC SEDIMENTS (LARGELY INFERRED)

GRAVITY CONTOUR PLAN

(whole area)

SCALE IN FEET

1000 0 1000 2000 3000

FOR THE CALCULATION OF BOUGUER ANOMALIES 2.2 g /cm^3 HAS BEEN ADOPTED AS AN AVERAGE ROCK DENSITY AND THE LATITUDE CORRECTION APPLIED. CONTOUR INTERVAL 0·25 MILLIGALS. BASE STATION AT C'500 E.

I55/B7-17

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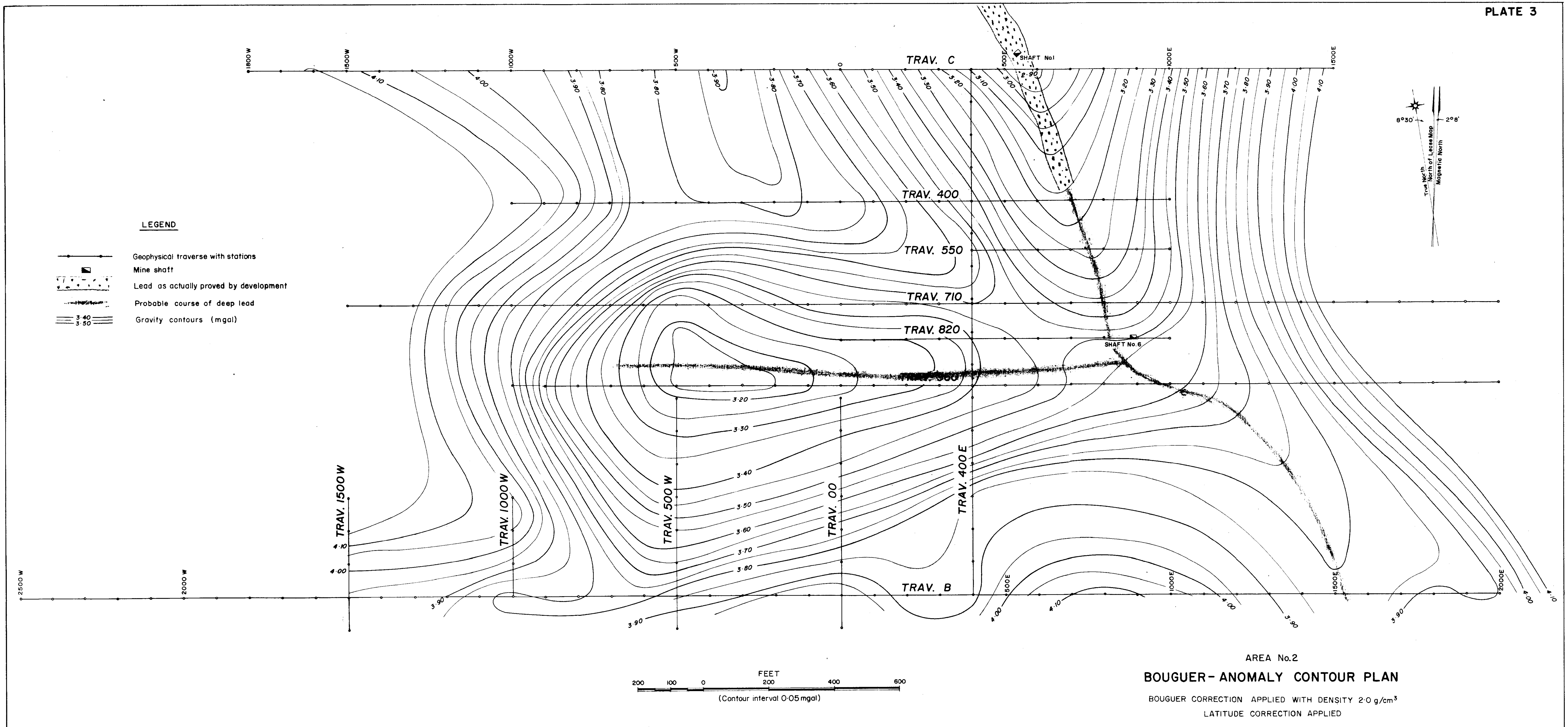
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

YITHAN, N.S.W. 1959

PLATE 3



AREA No.2

BOUGUER-ANOMALY CONTOUR PLAN

BOUGUER CORRECTION APPLIED WITH DENSITY 2·0 g/cm³

LATITUDE CORRECTION APPLIED

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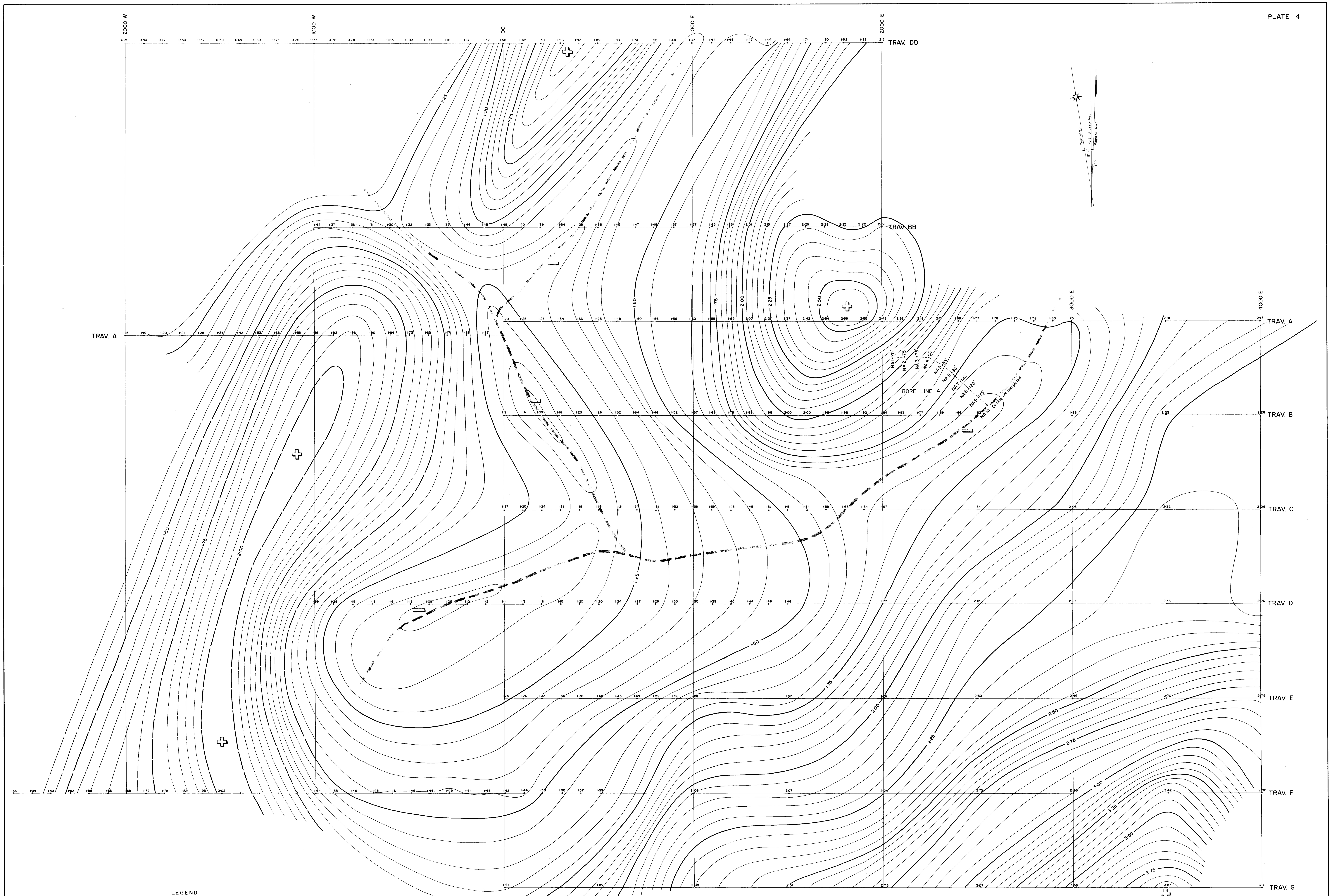
LOWER YITHAN, NSW 1959

PLATE 4



AREA No. 3

BOUGUER - ANOMALY CONTOUR PLAN

FOR THE CALCULATION OF BOUGUER ANOMALIES 1·8g /cm³ HAS BEEN ADOPTED AS AN AVERAGE ROCK DENSITY. CONTOUR INTERVAL 0·05 MILLIGALS.

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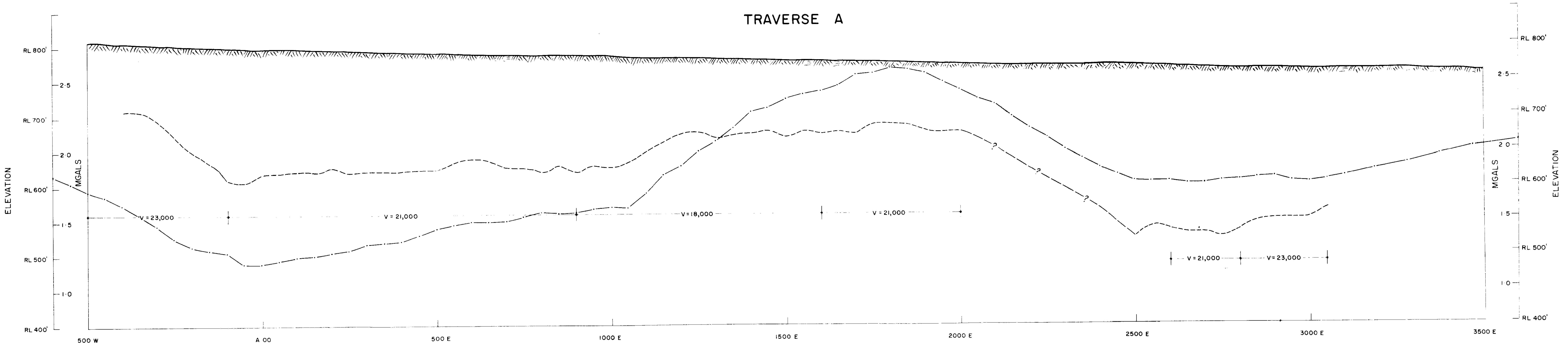
TRAVERSE A



LEGEND

- SURFACE PROFILE
- BEDROCK PROFILE (FROM SEISMIC RESULTS)
- V = 23,000 SEISMIC VELOCITY (FEET PER SECOND)
- GRAVITY PROFILE

SEISMIC AND BOUGUER-GRAVITY PROFILES, TRAVERSE A IN AREA No. 3

BOUGUER PROFILE CALCULATED WITH ROCK DENSITY 1·8 g/cm³

SCALES IN FEET

HORIZONTAL 200 0 200 400 600 800

VERTICAL 100 0 100 200 300 400

155/B7-23

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YITHAN NSW 1959