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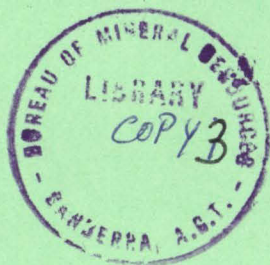
REPORT No. 94

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**Blair Athol Coalfield Gravity  
Survey, Queensland 1959**

BY

F. J. G. NEUMANN



*Issued under the Authority of the Hon. David Fairbairn  
Minister for National Development*

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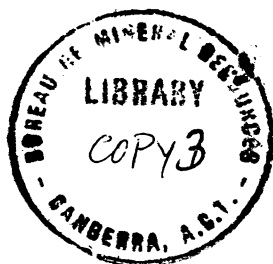
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DEPARTMENT OF NATIONAL DEVELOPMENT

MINISTER: THE HON. DAVID FAIRBAIRN, D.F.C., M.P.

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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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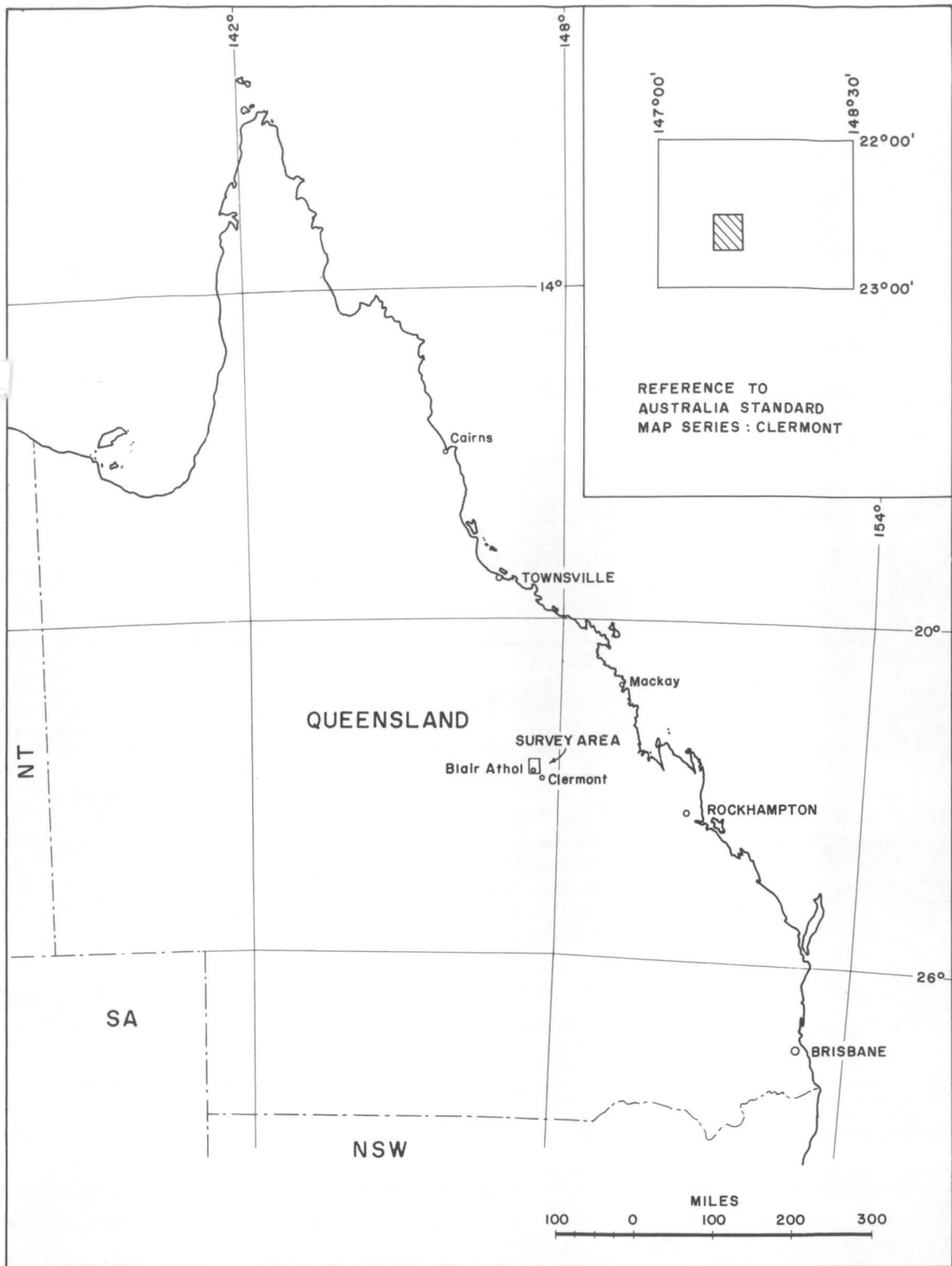


Figure 1. LOCALITY MAP

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### SUMMARY

A detailed gravity survey by the Bureau of Mineral Resources, Geology & Geophysics in 1959 showed that a distinct gravity "low" is linked with the main coal basin at the Blair Athol coalfield.

Distinct gravity "highs" on the eastern and south-eastern limb of the coal deposit indicate raised areas of basement rocks unfavourable to thick coal development. Strong gravity gradients suggest a rapid thinning of the coal measures on the north-western margin of the coalfield.

## 1. INTRODUCTION

At the request of Consolidated Zinc Pty Ltd a detailed gravity survey was made by the Bureau of Mineral Resources, Geology & Geophysics at the Blair Athol coalfield in East-Central Queensland (Fig. 1) during March 1959. At the same time a gravity reconnaissance was conducted over the area of outcropping coal measures north of the coalfield.

The Bureau's gravity survey was not the first geophysical investigation to be made in the Blair Athol area. In 1939 a field party of the Aerial, Geological and Geophysical Survey of Northern Australia used gradiometer, electrical resistivity, and experimental magnetic methods with the object of determining the north-eastern, northern, and western boundaries of the coal (AGGSNA, 1940). As a result of this the limit of thick coal was fairly accurately delineated over an appreciable distance.

Seven exploratory boreholes were subsequently drilled between May and December 1947, to investigate further the economical coal development on the north-eastern side of the coal basin (Reid, 1948). The results of this drilling are shown in relation to the gravity data in Plate 5 of this Report.

Five of the boreholes (Numbers 1 to 5, Plate 3) were drilled in a northerly line, at intervals of seven or eight hundred feet, in an area that was recognised as non-prospective on the strength of the 1939 gravity results. All of these boreholes encountered only thin coal seams of non-commercial value, together with carbonaceous shale and bands of sooty and weathered coal. One of the boreholes (No. 2) struck basement rocks at the relatively shallow depth of 142 ft below the surface.

The other two holes (No. 6 and 7, Plate 3) were drilled a little south of the previous ones, at places where the 1939 gradiometer results indicated the probable presence of thick coal. These holes penetrated solid black coal of appreciable thickness. The primary object of the present gravity survey was to investigate a possible northern extension of the productive coal measures in order to increase the known coal reserves. The survey would also provide data on the configuration of the basement underlying the coal measures, and so would assist in clarifying the tectonic setting of the basement structure as a whole.

## 2. GEOLOGY

The Blair Athol coal deposit has been described by Reid (1936, 1948) and the Geological Survey of Queensland (1953), among others. It is an isolated and relatively small basin of Permian lacustrine beds, about 50 miles west of the major Bowen coal basin of Eastern Queensland. It lies ten miles north-west of Clermont and roughly 130 miles, in a direct line, from the coast.

The "Big seam" of this deposit, with a maximum thickness of 108 ft, is one of the thickest seams of solid black coal ever recorded. The Blair Athol coal measures are of Upper Bowen (Upper Permian) age and lie virtually undisturbed in a basin of metamorphic sediments consisting of Clermont Series slate of possible Devonian age. Younger volcanics, as Tertiary basalt, occur as cover rocks mainly in the northern and south-eastern portion of the coal-bearing area.

Of the three coal seams known in the Blair Athol area, only the Big seam, also called the "Middle seam", was being worked at the time of the survey. The companies involved were Blair Athol Open-cut Colliery Pty Ltd and Blair Athol Coal and Timber Company Ltd. Average coal production during the previous few years was about 300,000 tons per annum. The Blair Athol coalfield is probably unique in that open-cut winning of the coal may be feasible for the entire reserves. These occur beneath an overburden of sandstone, shale, and some basalt, ranging in thickness from 25 to 135 ft.

Permian sediments and Tertiary basalt occupy a large area north and east of the known coal deposits, and it was considered possible that other coal deposits of economic importance might lie concealed within this area.

### 3. FIELD WORK

Field work was done by B.C. Barlow, geophysicist, between 9th and 28th March 1959, and 325 new gravity stations were observed. A gravity tie was made to Pendulum Station No. 50 at Clermont, where an observed gravity value of 978,776.4 milligals had been established by the Bureau in 1951 (Dooley *et al.*, 1961, Table 8).

Gravity stations were distributed on 17 east-west traverses covering the known coal-bearing area and its possible extension to the north as far as the Drummond Range. On the average these gravity traverses were half a mile apart. They followed alternate survey lines that had been used to establish the drilling grid. In order to provide a denser coverage on areas of rapid gravity variation, a few shorter traverses were run at quarter-mile intervals between the main traverses. Gravity observations were generally made at quarter-mile intervals, with additional stations at shorter spacing where necessary. For the reconnaissance of the extension of the coal measures north-west of the Drummond Range, a network of seven gravity traverses three-quarters of a mile apart was surveyed with stations at quarter-mile intervals. All the topographic surveying of gravity stations was done by Enterprise Exploration Company Pty Ltd, a subsidiary of Consolidated Zinc Corporation; the land survey comprised about 50 miles of traverses.

Station levels were computed to the nearest 0.01 ft and referred to Queensland State Datum, which corresponds to Mean Sea Level, Brisbane. Consolidated Zinc Corporation supplied topographic base maps, from which gravity plans were prepared in the Geophysical Branch of the Bureau.

The gravity meter used throughout the survey was Worden No. 140. The time drift of this meter was closely checked by re-occupying a gravity base station near the Clermont/Blair Athol road at the beginning and at the end of each day's field work, and also by regularly repeating readings on previously observed stations. Drift was fairly regular, with a mean rate of 3.25 scale divisions per day during the period of the survey. An accurate drift curve was drawn for each day of field work, using the readings at the base station and those at the re-occupied stations. From this curve the drift correction to be applied at the time of each field observation was determined. Only small discrepancies occurred when a station was read on more than one day: in a few instances these reached a maximum of plus or minus 0.04 mgal.

A calibration factor of 0.11133 mgal per scale division was used in the reduction of the gravity-meter readings. This factor had been determined before the survey by calibrating the meter against observed gravity values of base stations near Melbourne.



#### 4. DISCUSSION OF RESULTS

The results of the gravity survey are presented in the form of Bouguer anomaly contours in Plates 2 to 4. Plate 2 shows the whole survey area; Plate 3 shows more detail but covers the southern part only (i.e. the Blair Athol basin).

A uniform rock density of  $2.2 \text{ g/cm}^3$  between station site and sea level was used for calculation of Bouguer anomalies. This density was chosen as being representative of near-surface layers consisting of sandstone, shale, and some basalt. A higher density ( $2.65 \text{ g/cm}^3$ ) would be more appropriate to eliminate the topographic effect of the older Palaeozoic rocks that crop out in the survey area. However, any error due to adopting the wrong density value must be relatively small, as variations in elevation are moderate and outcrops of older Palaeozoic rocks are limited in extent.

It was expected that basalt of appreciable and variable thickness would offer some problems in the final interpretation of Bouguer anomalies, as the density of basalt is relatively high. Before completing the geophysical survey the gravity effect of the basalt was difficult to assess, owing to the absence of data on possible variations in its thickness and density. For this reason, no attempt was made to apply corrections for the presence of basalt before gravity reductions were completed. Later on, when the Bouguer anomalies had been computed and contoured, it was evident that any gravity variations due to the presence of basalt must be relatively small. There is no noticeable relation between the major trends of the gravity contours and the geological boundaries of the basalt.

In the plates that accompany this Report the exact positioning of Bouguer contours is subject to some doubt in places where gravity stations are sparse. However, the overall contour pattern reveals some significant anomalies in the survey area. These are described below:

- (a) The most outstanding feature of the anomaly pattern is the roughly triangular-shaped gravity "low" that is approximately defined and enclosed by the 11-mgal contour. It covers an area of about two-and-a-half square miles and extends on both sides of Washpool Creek. For convenience, this anomaly is referred to as the "Blair Athol low". The lowest Bouguer value (9.44 mgal) occurs near its centre. The north-western margin of the "Blair Athol low" is marked, over a distance of about three miles, by contours running north-east to north-north-east with steep gravity gradients. On the southern margin of the "Blair Athol low" the trend of the contours is generally easterly and the gradients are less steep. On the north-eastern, eastern, and south-eastern margins of the "Blair Athol low" the contours show no uniform trend. The 10.5-mgal and 11-mgal contours run due east over a certain distance of the north-eastern limb of the "Blair Athol low" and then swing rather abruptly from east to almost due south in the area of ML69 and ML68 (see Plate 2). Immediately north of the township of Blair Athol, contours again swing east for a distance of about one mile. Farther east again, in the area of ML56, the trend of the gravity contours is again mainly south.
- (b) Two significant gravity "highs" protrude into the eastern and south-eastern margin of the "Blair Athol low". One of these is a tongue-like anomaly feature, which is centred some distance north of the township and immediately north-east of Blair Athol No. 2 Colliery, where a closure occurs in the 12-mgal contour. The other, a more isolated "high" is centred south-east of Bath Creek, and has a

maximum Bouguer value of 12.83 mgal, just south of the railway line to Clermont. A horseshoe-shaped zone of low gravity intensity encloses this "high" to the east, south, and south-west.

- (c) Outwards from the "Blair Athol low", Bouguer anomaly values increase to maxima. There is probably a closure in the 12.5-mgal contour south-west of the Blair Athol Opencut Collieries workings east of Washpool Creek (Plate 3). East of the "Blair Athol low", the Bouguer values exceed 14 mgal on a north-east-striking feature. This difference of gravity intensity between the western and eastern sides of the "Blair Athol low" indicates the existence of a regional gravity gradient superimposed on the more local anomaly feature. This gradient amounts to about 1.5 mgal over a distance of three miles.
- (d) A relatively weak gravity "low" of somewhat irregular shape extends north and then north-west from the "Blair Athol low". This "low" deepens near the Drummond Range and probably closes around a minimum Bouguer value of 10.75 mgal.
- (e) A strong regional gravity gradient, which is negative to the north-west, finds its expression in roughly parallel gravity contours north of the Drummond Range. For comparison, Plate 4 shows the anomaly pattern with this regional gradient removed on the portion north of the Drummond Range. This corrected contour pattern in the area north of the Drummond Range is one of irregular alignment of alternating gravity "high" and "lows" except in the west, where relatively low Bouguer values prevail along a distinct zone of north-north-west strike.

## 5. ANALYSIS OF RESULTS

In principle the evaluation of the gravity anomalies in the Blair Athol area offers no special difficulties. The geological setting is mainly one of near-horizontal and almost undisturbed sediments of low density deposited in a shallow basin formed by rocks of comparatively high density. The problem is simplified in that the geology of the coal occurrence is well known from mining operations and numerous boreholes drilled for coal exploration.

It is immediately evident from an inspection of the gravity pattern that the major gravity deficiency, the "Blair Athol low", coincides with the known coal basin where the greatest thickness of coal exists beneath an overburden of younger rocks. It is also obvious that, in a fringe zone around the coal basin, gravity values are relatively high near the outcrops of older Palaeozoic rocks.

### Rock densities

The densities of the rocks in the Blair Athol area have been determined by several investigators over a period of more than twenty years. The values are shown in Table 1. The density of some of the basalt may be as high as 3.09 g/cm<sup>3</sup>. However, the later testing of several cores of unweathered basalt from borehole M22 near the eastern boundary of the coalfield shows that its density varies between fairly wide limits. The mean value found in these tests was 2.79 g/cm<sup>3</sup>, and this may be representative of the unweathered basalt. When the effect of weathering is taken into account, the average density of the basalt as a whole may be significantly lower, and may not differ greatly from that of the basement rocks (Clermont Series).

TABLE 1. ROCK DENSITIES. BLAIR ATHOL COALFIELD

<u>Type</u>	<u>Age/Locality</u>	<u>Density (g/cm<sup>3</sup>)</u>	<u>Year determined</u>
Basalt	Tertiary/Newcastle Extended shaft	3.09*	1939
Basalt	TERTIARY/Bore N22	2.79*	1959
Clermont Series	DEVONIAN (?)	2.84	1939
Clermont Series	"	2.65*	1939
Shale	PERMIAN	2.38	1939
Sandstone	PERMIAN	2.23*	1939
Overburden, including shale, sandstone, grit	Post-PERMIAN	2.20*	1958
Coal	PERMIAN	1.39	1936
Coal	"	1.33	1939
Coal	"	1.28*	1958
Soot	-	1.05	1939
Soil, black & sandy	RECENT	1.4 - 2.0	1939

\* Note : Density values shown with an asterisk are mean values obtained from tests on several specimens. Densities shown were determined by the following investigators:

J.H. Reid	1936
R.F. Thyer	1939
R.N. Spratt	1958
I. Whitcher	1959

As mentioned earlier, the gravity anomaly pattern does not appear to be influenced appreciably by the distribution of the basalt. The reasons suggested for this are:

- (1) It is presumed that the basalt is relatively thin as suggested by Reid (1936).
- (2) The density of much of the basalt may have been reduced by weathering.
- (3) During the initial stage of deposition the basalt may be vesicular, and so of lower density.

The second-highest rock densities in Table 1 are those for the Clermont Series; a mean density of 2.65 g/cm<sup>3</sup> was obtained from tests of several specimens. Analysis of the correlated gravity and geological cross-sections (described later) indicates that a density of 2.65 to 2.70 g/cm<sup>3</sup> is most probably representative of the Clermont Series rocks as a whole. One specimen listed in Table 1 had an appreciably higher density (2.84 g/cm<sup>3</sup>) than the mean value for the Clermont Series. This indicates the possibility of lateral variations in the density of the rocks that comprise the basement under the Blair Athol coal beds. Substantial density variations within major portions of the basement complex would give rise to gravity anomalies that would be superimposed on those due to other causes.

The lowest rock densities listed are those of soot (1.05 g/cm<sup>3</sup>) and Blair Athol coal (1.28 g/cm<sup>3</sup>). Soot occurs only to a limited extent within, or overlying, the coal seams; its presence would have little effect on the density of the coal seams as a whole.

Although coal constitutes the greater part of the Permian sediments down to the basement of the coal basin, Table 1 gives densities measured on other rock types; e.g. shale, with a density of 2.38 g/cm<sup>3</sup> and various types of sandstone with a mean density of 2.23 g/cm<sup>3</sup>. Conglomerate occurs at the base of the coal measures, but specimens were not available for density tests. However, the mean density of Permian conglomeratic beds can be assumed to be about 2.5 g/cm<sup>3</sup>. The bulk density of the Permian sediments (other than coal) including sandstone, shale, and conglomerate is assumed to be approximately 2.4 g/cm<sup>3</sup>.

From the analysis of the gravity variation along the known cross-sections the bulk density of the coal measures, including the coals that fill the Blair Athol basin, appears to vary within the limits 2.1 to 2.3 g/cm<sup>3</sup>. This finding agrees reasonably well with the results of the density determinations mentioned above. It can be illustrated in terms of cross-sections G-H and A-B-C (see Plates 5 and 3) as follows:

An assumed column of sediments, representative of conditions similar to those shown along cross-section G-H, with a total thickness of 800 ft, comprising 700 ft of clastic rocks (density = 2.4 g/cm<sup>3</sup>) and 100 ft of solid coal (density = 1.3 g/cm<sup>3</sup>) has an average density of 2.26 g/cm<sup>3</sup>.

In contrast, a column representative of conditions similar to those along cross-section A-B-C, with a total thickness of 400 ft, comprising 300 ft of clastic sediments and 100 ft of coal, of the same densities as before, has a mean density of approximately 2.1 g/cm<sup>3</sup>.

### Interpretation principles

Basically the geophysical problem was to determine from the gravity data the distribution of coal measures whose average density ranges from approximately 2.1 to 2.4 g/cm<sup>3</sup> (depending on the relative amount of coal present) overlying a basement of Clermont Series rocks whose average density is 2.65 to 2.70 g/cm<sup>3</sup>. The amount by which gravity is reduced by the presence of the relatively light coal measures depends on their thickness and average density. The magnitude of the maximum gravity deficiency sets an upper limit to the probable thickness of the coal measures.

The maximum gravity difference observed over the area of the coalfield is approximately three milligals. This is the difference between the values established near the outcrops of Clermont Series rocks (approximately 12.5 mgal) and the values near the centre of the "Blair Athol low" (9.44 mgal).

Table 2 shows the thickness of coal measures that would cause an anomaly of three milligals, for a range of density contrasts between the coal measures and the underlying Clermont Series rocks. The range considered is probably appropriate to the Blair Athol coalfield.

TABLE 2. THEORETICAL THICKNESS OF COAL MEASURES

<u>Density difference between coal measures and basement</u> (g/cm <sup>3</sup> )	<u>Total thickness of coal measures</u> (ft)	<u>Max. gravity variation</u> (mgal)
0.6	400	3
0.5	470	"
0.4	600	"
0.3	800	"

### Analysis of cross-sections

Four typical cross-sections (A-B-C, C-E-F, B-B-C-D, and H-G) were chosen to analyse the gravity results in relation to geology. The horizontal projections of these section lines are shown in Plate 3. Plate 5 shows the cross-sections, with Bouguer anomaly curves superimposed on geological data obtained from boreholes, shafts, and known outcrops. Probable densities of the formations were computed and the probable depth to basement was determined from the gravity anomaly data. Where the basement depth was known from drilling, this is plotted.

In order to prepare the gravity profiles for precise analysis it was necessary to eliminate the regional gradient, which amounts to 1.5 mgal over about three miles and is negative to the north-west as described above.

Cross-section A-B-C. This runs east-south-east from a point 1600 ft west-north-west of the Newcastle West shaft towards borehole No. 3 and then turns south towards borehole No. 6. From the western end the gravity values decrease rapidly to the Newcastle

West shaft. This steep gradient coincides with the western edge of the Blair Athol basin and is caused in part by the rapid thickening of the coal in the Big seam and partly by an increase in thickness of the Permian beds as a whole. At the Newcastle West shaft, basement was reached at 409 ft. The gravity data suggest that east of the shaft the basement most probably deepens by another 100 ft. This interpretation is supported by borehole J17, in which the top of the Big seam was encountered about 70 ft lower than in the Newcastle West shaft.

Farther east, a gradual rise in gravity values suggests a progressive rise of the basement floor towards Newcastle Colliery main shaft and towards boreholes No. 3 and 2. At No. 2, basement was struck at 142 ft, indicating that this is near the eastern margin of the basin. Near the margin of the coal occurrence, the Big seam is split into several thin seams containing coal, carbonaceous shale, and shale with coal bands (Reid, 1948). Immediately west of borehole No. 3 the gravity gradient shows a local steepening; this is most probably caused by a rapid thinning of the coal in the Big seam towards the eastern margin of the basin, and by the transition from solid black coal to inferior coal and carbonaceous shale.

The striking of bedrock in borehole No. 2 at relatively shallow depth was not unexpected at the time of the drilling (1947). As a result of the gravity gradiometer survey of 1939 it had been predicted that the section tested by boreholes No. 1 to 5 was east of the eastern margin of the Big seam and that basement would be relatively shallow. With the more complete gravity data now available this basement "high" can be described more exactly. Basement rock appears to extend as a narrow spur at shallow depth south-south-eastwards from a major ridge of basement rock, which is aligned mainly eastwards and east-south-eastwards. Gravity data suggest that this main ridge extends east from the Newcastle Extended shaft over a distance of roughly two miles. This ridge of shallow basement evidently lies east of the main Blair Athol coal basin; no commercial coal seam was intersected in the Newcastle Extended shaft and none of the boreholes (No. 1 to 5) drilled in the area outlined by the gravity "high" encountered coal of appreciable thickness.

In calculating the basement profiles west of borehole No. 3 a value of 0.55 to 0.51 has been used for the density contrast between the coal measures and basement. This is consistent with the cross-sections where known, and gives the correct depth at the Newcastle West shaft.

Cross-section B'-B-C-D. This shows the geological information obtained from the boreholes sunk in 1947 (No. 1 to 8) in relation to the Bouguer anomalies. This section line runs south from borehole No. 5 to No. 6 and then swings east to No. 8. The upper cross-section (Plate 5) is plotted to natural scale; below it is the same cross-section with exaggerated vertical scale to emphasise stratigraphic detail.

The depth to the basement is established by two boreholes, No. 2 and 7, which penetrated the Clermont Series at depths of 142 ft and 577 ft respectively. In the anomaly curve certain allowances were made for the regional gradient and for a local gravity anomaly that may be caused by basalt, which is present in borehole No. 8.

Between No. 5 and No. 1 the gravity value is relatively high, corresponding to shallow basement and the absence of any appreciable thickness of relatively light coal. It reaches a maximum at No. 2, where basement is shallowest; it also rises to a high value at the extreme eastern end of the section, where presumably basement is also very shallow. Passing from No. 2 to No. 6 and 7, the gravity value decreases rapidly, owing to the presence of a large thickness of the Big seam and a rapid deepening of the basement. Farther east the

gravity again increases, owing to a progressive rise in basement and a decrease in the amount of coal. The geological cross-section at borehole No. 8 rather suggests that the upper part of the Big seam has been eroded by an ancient stream channel, which has later been filled by a basalt flow.

Cross-section C-E-F. This runs south-west from borehole No. 6 towards Bluff Colliery, and then swings due south across the southern margin of the coal basin. The Bouguer anomaly profile, with the regional gradient removed, indicates that between No. 6 and the Eldorado shaft the basement is most probably flat and at a depth of about 600 ft. The profile indicates that from a point one-eighth of a mile south of Eldorado shaft, the basement commences to rise to the south. Associated with this rise the Big seam gradually thins towards Bluff Colliery, where 40 ft of coal is reported. Near the southern end of cross-section C-E-F, coal finally wedges out. The very gradual rise in gravity intensity to the south indicates a similar gradual rise in basement.

Owing to the absence of gravity data on the southernmost portion of cross-section C-E-F, the profile was projected onto the section line from stations farther east. No control on depth to basement was available from drilling on cross-section C-E-F. The plotted basement profile was computed solely from gravity data by assuming a density of 2.65 g/cm<sup>3</sup> for the bedrock and 2.33 g/cm<sup>3</sup> for the total thickness of Permian sediments.

Cross-section H-G. This runs south-east across the main basin structure through Imbel shaft to the Blair Athol Coal and Timber Co. workings and half-way between boreholes M14 and M15, N15 and N16, O16 and O17. The Bouguer profile, corrected for regional gradient, reaches a minimum immediately west of borehole N16, where basement is presumably deepest. Farther west the gravity increases gradually with an appreciable steepening in gradient between boreholes M15 and M14 as the western margin of the basin is approached.

From the analysis of cross-section H-G it is obvious that the gravity minimum on this particular portion of the coal basin cannot be explained by variations in thickness of coal contained in the Big seam. In fact thickness of coal, as drilling results show, remains very much the same between the Blair Athol Coal and Timber Co. workings and borehole M15. The Big seam is approximately 100 ft thick over a distance of 1.5 miles across the whole width of the coal basin.

On the other hand, the amplitude of the gravity "low" near N15 indicates a total maximum thickness of Permian sediments of roughly 800 ft (assuming, as before, a density of 2.65 g/cm<sup>3</sup> for basement rocks and 2.33 g/cm<sup>3</sup> for Permian sediments). There appears to be a local depression in the basement floor between N15 and N16, and the deepest portion of the Blair Athol basin is probably under the area approximately outlined by the 9.5-mgal gravity contour.

The steep gravity gradient between M15 and M14 is due to the combined effects of the Big seam cutting out and a steep rise in the basement floor. There is a similar steep gradient at the western end of cross-section A-B-C. The gravity contours in Plate 3 show that this steep gradient persists throughout the north-western margin of the Blair Athol basin, at least between traverses I and N. Over this distance, basement shallows rapidly and the Big seam terminates abruptly.

No attempt has been made to analyse the relation between gravity anomalies and geology in the south-eastern portion of the Blair Athol field, south-east of Bath Creek.

Gravity readings on a few stations spread out over this area indicated an isolated gravity "high", but it would require a denser coverage to delineate this feature accurately. Furthermore, no information on depth to basement was available at the time this Report was written. An overall consideration of the gravity contours in relation to known coal thickness shows clearly that a thick coal seam occurs in the area of the horseshoe-shaped gravity "low" that encloses the "high" to the east, south, and south-west. Near the centre of the gravity maximum the coal in the Big seam has thinned considerably or the Big seam has split into several smaller seams. This shows that the area outlined by the gravity "high" is unfavourable to thick coal deposition and is most probably underlain by basement rock at shallow depth.

#### Assessment of coal reserves

One of the main objectives of the gravity survey was to prospect for additional coal deposits that might be concealed beneath Permian sediments or Tertiary basalt, or both, in the area south and east of the Blair Athol basin. The gravity results indicate that no major extension of the Blair Athol coal basin is present in the area immediately north or east of the known field. Reference has been made earlier to the weak gravity "low" that extends west and north-west of the Newcastle Extended shaft and deepens near the Drummond Range to a closed minimum. This "low" most probably indicates a depression in the basement floor containing Permian sediments. The area of this "low" is less than one-sixth that of the "Blair Athol low", and the maximum amplitude of the anomaly is approximately 0.5 mgal compared with 3 mgal for the "Blair Athol low". An anomaly of 0.5 mgal can be explained by a basement depression 200 ft deep filled with sediments that differ in density from the basement by 0.2 g/cm<sup>3</sup>. In a consideration of additional coal reserves this looks most unpromising, but nevertheless the possibility of coal being found in significant quantities cannot be ruled out entirely, and a test borehole is warranted.

The results of boreholes No. 7 to 17, in the Parish of Miclere (see Plate 2) north of the Drummond Range, indicate that there are variations in the depth to basement with no commercial coal accumulation in the Permian coal measures. From an inspection of the related amplitudes in the gravity contour pattern, it can be inferred that, at least to some extent, higher gravity intensity corresponds to a relative rise in the basement floor and lower gravity to a relative deepening of the basement floor.

The irregular alignment of relatively small gravity "high" and "lows" in the area north of the Drummond Range could be explained by the existence of horizontal density variations in the basement complex. Density variations of sufficient magnitude can give rise to Bouguer anomaly variations that would appear superimposed on the anomalies due to sediments of varying thickness deposited on an uneven basement floor.

In the Blair Athol basin there is a close correlation between gravity values and coal distribution. Four subdivisions can be recognised in the coal-bearing area. These subdivisions, which are shown in Plate 6 by circled numbers 1 to 4, are briefly described as follows:

- (1) The main coal deposit is defined by a gravity contour that runs approximately between the 10.5-mgal and 11.0-mgal contours. In a general manner this line corresponds to the 60-ft coal isopach obtained by interpolation between drilling data.
- (2) A south-eastern extension of the main coal basin is expressed by the horseshoe-shaped gravity "low" that surrounds the isolated gravity "high" south of Bath Creek.



- (3) An area of marginal coal development north, north-east, and east of the main coal occurrence was fairly accurately defined by the 1939 gradiometer survey. The gravity contours based on results of the 1959 survey confirm and supplement the delineation of the coal boundary, mainly to the north and east.
- (4) The southern margin of gradually thinning coal coincides approximately with the southern limb of the "Blair Athol low", but the gravity information south of the main coal basin is not sufficient to establish the boundary of commercial coal in this particular portion of the coalfield with reasonable certainty.

Coal reserves in each of these four subdivisions were calculated, for the Big seam only, in the following way. Using empirical data on thickness of the seam obtained by drilling, shaft sinking, and mining, isopachs of coal thickness were drawn at 10-ft intervals on a map at a scale of 10 chains to one inch. A half-inch grid was superimposed over this, and the thickness at the centre of each square was estimated from the isopach lines; this was regarded as the average coal thickness over the area of the square. The volumes of coal in each square were summed and converted to tons by assuming a density of 1.28 g/cm<sup>3</sup>. The following figures were obtained:

<u>Subdivision</u>	<u>Estimated coal reserves</u> (millions of metric tons)
(1) Main coal basin	184.2
(2) South-eastern sub-basin	35.6
(3) Marginal coal north and north-east of main basin	8.5
(4) Marginal coal south of main basin (quantity estimate is very rough)	16.0
Total	<hr/> 244.3 <hr/>

These figures make no allowance for coal already extracted, or for coal losses due to tectonic displacement or fires, or for inferior coal.

## 6. CONCLUSIONS

The gravity survey has shown that, within the area surveyed, it is unlikely that any substantial coal reserves exist beyond the limits of the known Blair Athol deposit. A gravity "low" of small area and low intensity occurs on the western margin of the field near the Drummond Range. Although the chances of this "low" representing commercial coal are not considered good, it is considered nevertheless that a test borehole is warranted.

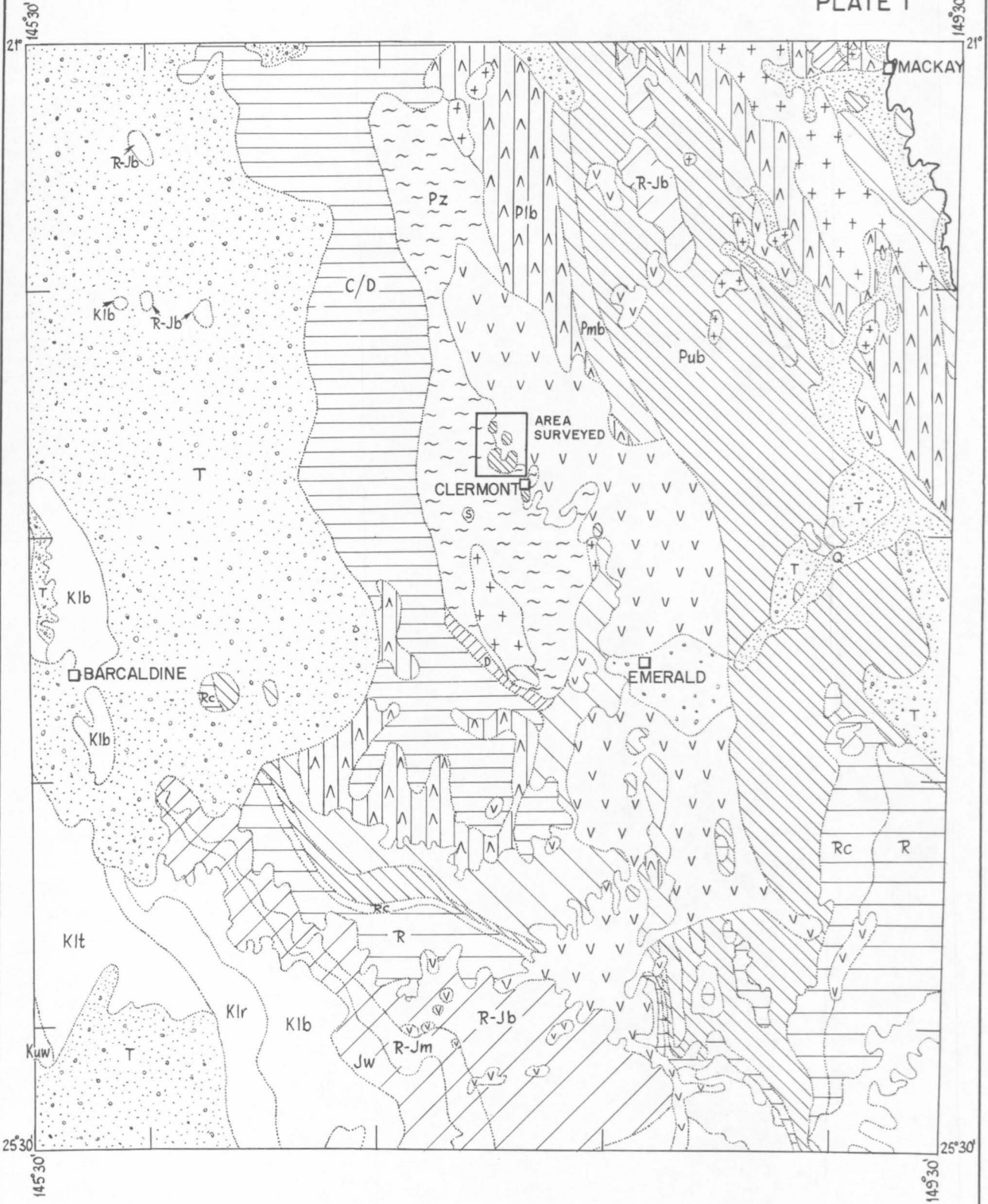
The gravity data over the Blair Athol deposit have given useful information on the basement configuration and have clarified the tectonics of the basin as a whole.

An empirical relation between the gravity contours and coal thickness will be useful in estimating the reserves of the Blair Athol deposit.

There seems little doubt that if coal deposits similar to that at Blair Athol exist under cover of superficial deposits beyond the survey area, they can be found by gravity surveys.

#### 7. REFERENCES

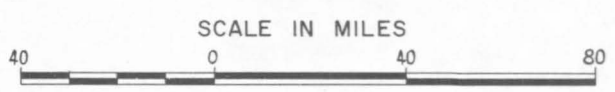
- |   |      |   |
|---|------|---|
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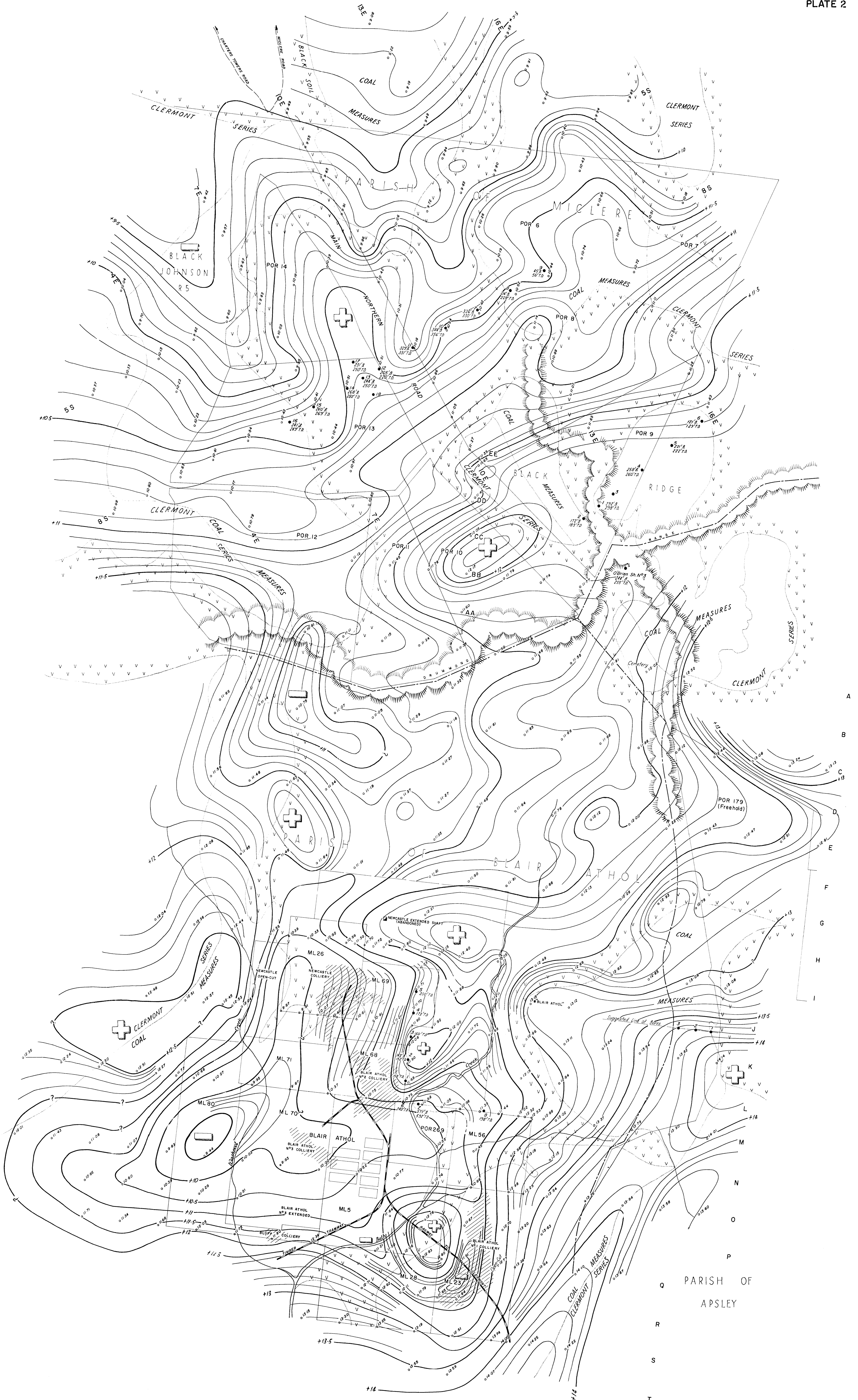
LEGEND

- |                                    |                       |
|------------------------------------|-----------------------|
| Quaternary                         | Basalt                |
| Tertiary                           | Granite               |
| Cretaceous                         | Serpentine            |
| Jurassic and Jurassic/Triassic     | Winton Formation      |
| Triassic                           | Tambo Formation       |
| Upper Bowen Coal Measures          | Roma Formation        |
| Middle Bowen Group                 | Blythesdale Group     |
| Lower Bowen Volcanics              | Walloon Coal Measures |
| Carboniferous/Devonian             | Marburg Sandstone     |
| Devonian                           | Bundamba Group        |
| Lower Palaeozoic (Clermont Series) | Clematis Sandstone    |

DETAILED GRAVITY SURVEY (1959)  
BLAIR ATHOL, QUEENSLAND  
REGIONAL GEOLOGY



After Geological Map of Queensland : 1953



LOCATION



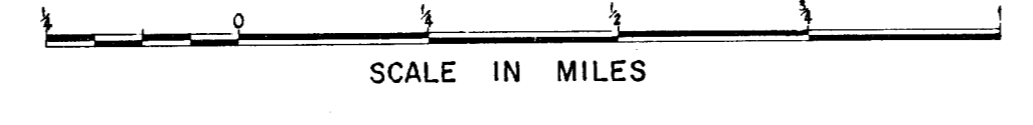
BUCHANAN	M <sup>o</sup> COOLM	MACKAY
GAILELLE	CLERMONT	ST. LAWRENCE
JERICO	EMERALD	DURANGO

MAP DATA

BASE MAP FROM GEOLOGICAL AND DRILLING PLAN, BLACK RIDGE AND APSLEY CREEK, A 023 NA, 1936, QUEENSLAND REPORT.  
 QUEENSLAND GOVERNMENT MINING JOURNAL VOL. 37, 1935, VOL. 47, 1946 AND VOL. 49, 1948

DETAILED GRAVITY SURVEY (1959)

BLAIR ATHOL, QUEENSLAND  
 BOUGUER ANOMALIES  
 AND GEOLOGY



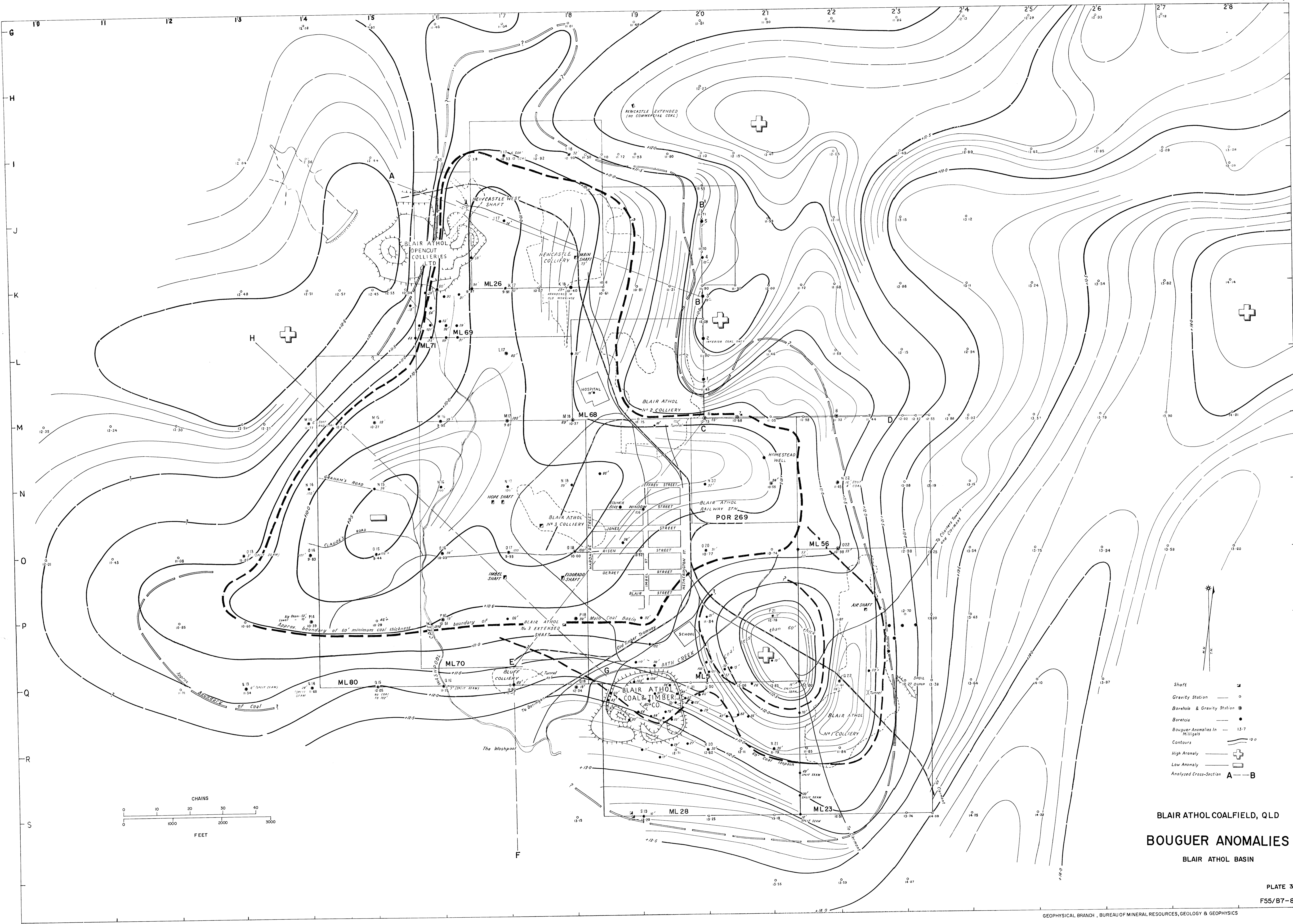
LEGEND

- GRAVITY STATION
- 5S TRAVERSE NUMBER
- 40.52 BOUGUER ANOMALY IN MILLIGALS
- ANOMALY CONTOUR, MILLIGALS
- ⊕ HIGH ANOMALY
- ⊖ LOW ANOMALY
- ▨ MINING OPERATIONS
- COAL EXPLORATION BOREHOLE
- GEOLOGICAL BOUNDARY
- BASALT
- PROBABLE LIMIT OF COMMERCIAL COAL (10% M<sub>41</sub>)
- 577.8' DEPTH TO BASEMENT
- 527.2' TOTAL DEPTH
- PARISH BOUNDARY
- MINING LEASE BOUNDARY

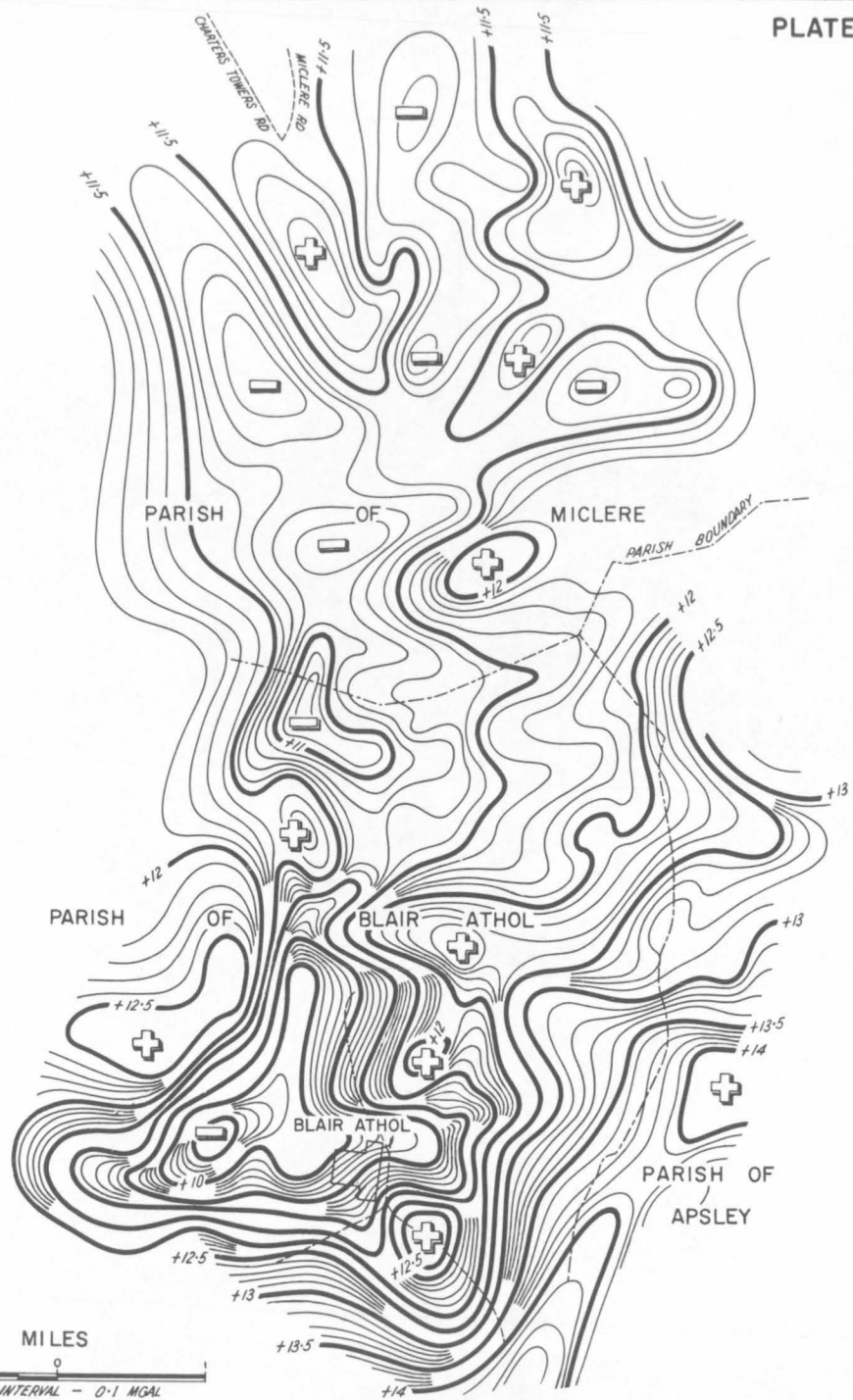
EXPLANATION

RELATIVE BOUGUER ANOMALIES ARE BASED ON OBSERVED GRAVITY VALUE OF 979,776.4 MILLIGALS AT B.M. N<sup>o</sup> 50 PENDULUM STATION, CLERMONT.  
 FOR THE CALCULATION OF BOUGUER ANOMALIES 2.20/GW<sup>3</sup> HAS BEEN TAKEN AS AN AVERAGE ROCK DENSITY.  
 GRAVITY FIELD SURVEYS BY GEOPHYSICAL BRANCH, B.M.R.  
 ELEVATION DATUM—QUEENSLAND STATE DATUM (M.S.L.)

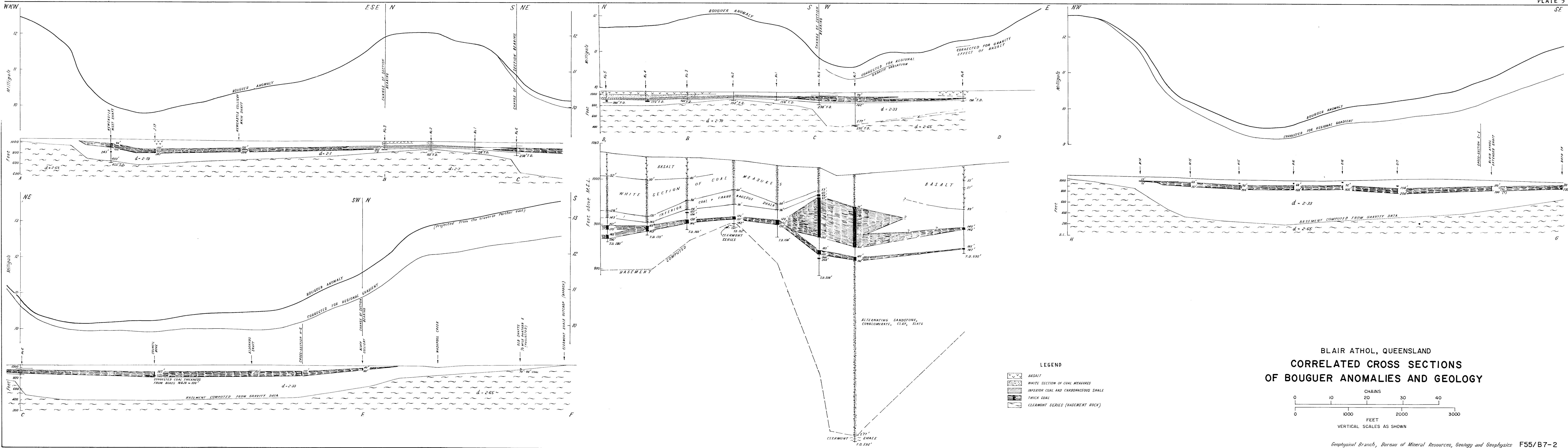
REFERENCE TO AUSTRALIAN NATIONAL 1:250,000 MAP SERIES

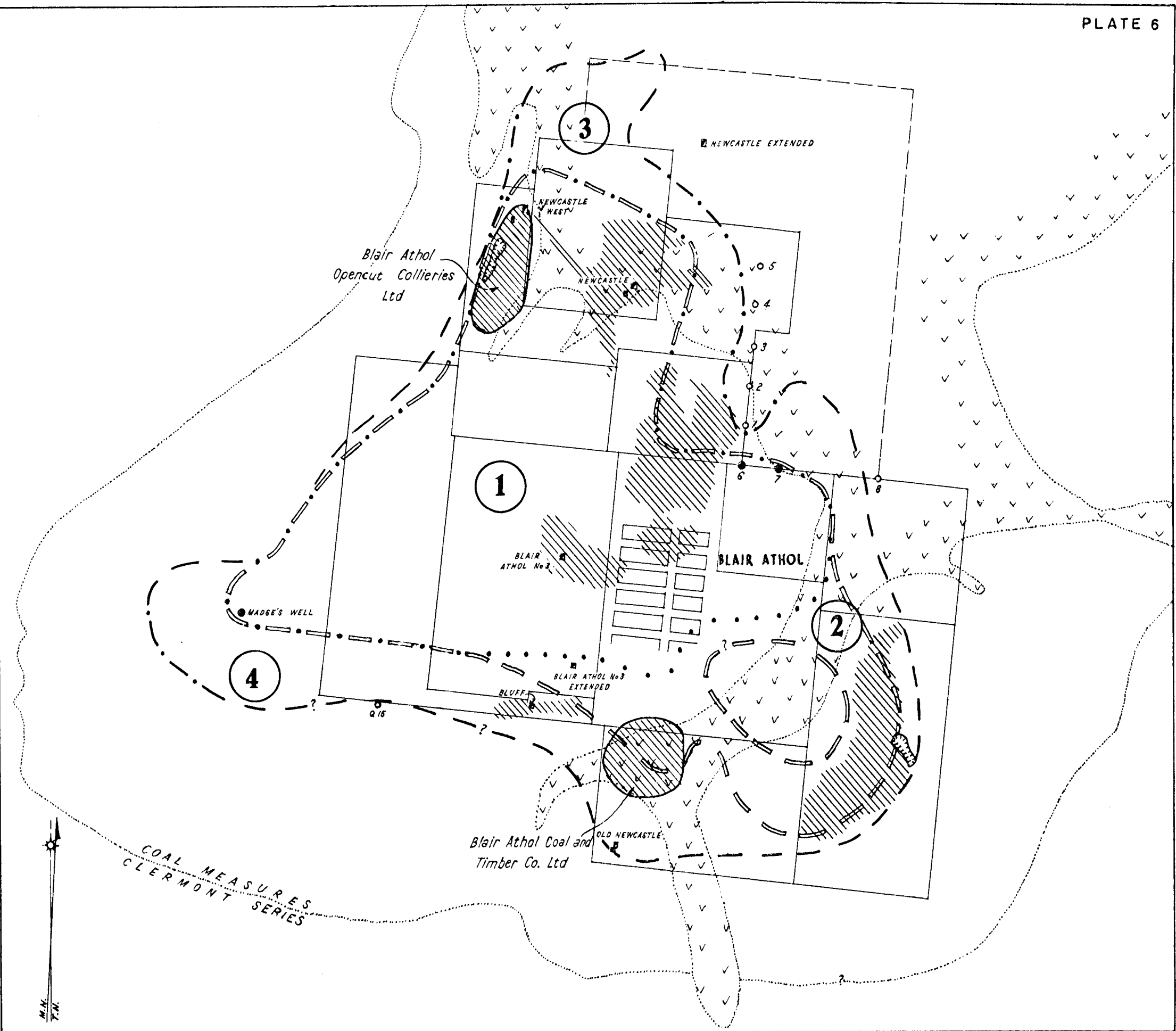


BLAIR ATHOL COALFIELD, QLD  
**BOUGUER ANOMALIES**  
 BLAIR ATHOL BASIN



BOUGUER ANOMALIES WITH MAIN REGIONAL GRADIENT REMOVED





LEGEND

- 60-FEET ISOPACH
- PROBABLE BOUNDARY OF THICK AND/OR COMMERCIAL COAL
- BOUNDARY OF THICK COAL (AGGSNA, 1938)
- " " MAIN COAL BASIN (BMR GRAVITY SVY 1959)
- GEOLOGICAL BOUNDARY (I.G. WHITCHER, 1959)
- BASALT
- COLLIERY WORKINGS (IN OPERATION/ABANDONED)
- OPEN-CUT " "
- EXPLORATION BOREHOLE (COAL OF APPRECIABLE THICKNESS)
- " " (NO COMMERCIAL COAL)
- SHAFT

BLAIR ATHOL COALFIELD, QLD  
DISTRIBUTION OF COAL RESERVES

