DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

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REPORT OF A GRAVITY SURVEY AT THE BLAIR ATHOL COALFIELD, QUEENSLAND.

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CONTENTS.

ILLUSTRATIONS.

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ABSTRACT.

A detailed gravity survey, carried out by the Bureau of Mineral Resources, Geology and Geophysics at the Blair Athol Coalfield in East-Central Queensland early in 1959, is described.

The results of the survey reveal that an expressive gravity "Low" is linked with the main coal basin.

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 at the coal measures on the northwestern margin of the Blair Athol field.

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1. INTRODUCTION.

At the request of The Consolidated Zinc Proprietary Limited a detail gravity survey was carried out by the Bureau of Mineral Resources, Geology and Geophysics at the Blair Athol coalfield in East-Central Queensland during the month of 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 is 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 delineating the northwestern, northern northeastern and a portion of the western boundary of the coal (Rayner and Thyer, 1939). As a result of this the limit of the thick coal was fairly accurately located over an appreciable distance.

Seven exploration bores were subsequently drilled from May until December, 1947, to investigate further the economical coal development on the northeastern side of the coal basin (Reid, 1948). The results of this drilling campaign are shown in relation to the recently obtained gravity data on Plate 5 of this report.

Five of the bores referred to (No.1 to No.5) were drilled at seven hundred to eight hundred feet intervals along a north running line on the area, which was recognized as non-prospective on the strength of the 1939 gravity results. All of these bores encountered only thin coal seams of non-commercial value together with carbonaceous shale and bands of sooty and weathered coal. One of the bores (No.2) struck basement rocks at the relatively shallow depth of 142 feet below the surface. On the other hand solid black coal of appreciable thickness was found by two bores (No.6 and No.7), which were drilled at such locations, where the gradiometer results of the 1939 survey had indicated the probability of the presence of thick coal.

The primary object of the recent gravitymeter investigation was to investigate a possible northern extension of the productive coal measures with a view to increasing the known coal reserves. The survey would also provide basic data on the configuration of the basement underlying the known coal measures which would be of assistance in clarifying the general tectonic setting of the basin structure as a whole.

2. GEOLOGY.

The Blair Athol coal deposit is an isolated and relatively small basin of Permian lacustrine beds, approximately fifty miles west of the major Bowen coal basin of eastern Queensland, ten miles northwest of Clermont and roughly at one hundred and thirty miles distance - in a direct line - from the nearest point of the Queensland coast.

The "Big" seam, which occurs in this field, is one of the thickest seams of solid black coal on record with a maximum thickness of 108 feet. 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 slates of possibly Silurian age. Younger volcanics, as Tertiary basalt, occur as cover rocks mainly in the northern and southeastern portion of the coal bearing area.

Three coal seams are known in the Blair Athol area. The "Big" seam, also called "Middle" seam, is the only one being worked at present by two companies, the Blair Athol Open-cut Collieries Pty. Ltd. and the Blair Athol Coal and Timber Company Limited. The average coal production during recent years has been approximately three hundred thousand tons per annum.

The Blair Athol coalfield is unique in that, in principle, open-cut winning of the coal should be feasible over the whole field. The entire coal reserves occur under an overburden comprising sandstone, shale and some basalt ranging from 25 to 135 feet thick.

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

3. CONDUCT OF FIELD WORK.

Three hundred and twenty-five new gravity stations were observed by B. C. Barlow, Geophysicist, during the period of the field work, which lasted from the 9th to 28th of March, 1959.

A gravity tie was made to Pendulum Station No.50 at Clermont, where an observed gravity value of 978,776.4 milligals was established during the course of earlier pendulum work in 1951 conducted by the Bureau (Dooley et al 1959).

Gravity stations were distributed on seventeen 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 are half a mile apart and follow alternate survey lines which were 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 northwest of the Drummond Range (Black Ridge), a network of seven gravity traverses three quarters of a mile apart were surveyed with stations at quarter mile intervals. All the topographic work required for fixing the station positions in the field was carried out by the Enterprise Exploration Co. Pty. Ltd., a subsidiary of the Consolidated Zinc Company; the land survey includes approximately a total of fifty miles of traverses.

Levels were computed to the nearest one hundredth of a foot and referred to the Queensland State datum, which corresponds to the Mean Sea Level mark at Brisbane. The Consolidated Zinc Company supplied topographic base maps, from which gravity plans were prepared in the Drawing Office of the Geophysical Section of the Bureau.

Gravitymeter Worden No.140 was used throughout the survey. The time drift of the instrument 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. The drift of the instrument was fairly regular and a mean driftrate of 3.25 scale divisions per 24 hours was determined for the period of the survey.

An accurate drift curve was drawn for each day of the fieldwork, using the readings at the base station and those at the re-occupied stations. From this curve the appropriate corrections for any time of the field observations was determined. Discrepancies which occurred when a station was read on more than one day are small and in a few instances reach a maximum of plus or minus four hundredths of one milligal.

A scale factor of 0.11133 milligals per division was used in the reduction of the meter readings. This factor was calibrated prior to the period of the survey against the observed gravity values of base stations near Melbourne.

4. DISCUSSION OF RESULTS.

The results of the Blair Athol gravity survey are presented in the usual form of Bouguer anomaly contour plans on Plates 2 to 4 of this report.

A uniform rock density (= 2.2 grammes per c.c.) 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 partially of basalt. A higher density (= 2.65) would be more applicable to eliminate the topographic effect of the older Palaeozoic rocks, which crop out in the surveyed area. However any error which might be found with the Bouguer anomalies due to an incorrect assumption of the rock densities must be relatively small as variations in elevation are moderate and outcrops of older Palaeozoic beds are of limited extent.

It was expected that basalt of appreciable and variable thickness would offer some problem in the final interpreting of Bouguer anomalies, as the density of basalt is relatively high. Prior to the completion of the geophysical survey the gravity effect of the basalt was difficult to assess owing to the absence of data relating to the possible variations in its thickness and density. For this reason no attempt was made to apply corrections for the presence of basalt in advance of the gravity reductions. Later on when the Bouguer anomalies had been computed and contoured, it was evident that gravity variations, which might be caused by 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.

Bouguer anomaly contours shown on the plates which accompany this report may be subject to small alterations as there is insufficient data to delineate precisely the anomaly features.

The overall pattern of the gravity contours reveals significant anomalies in the surveyed area, which are dealt with below:-

(a) The most outstanding feature of the anomaly pattern is the roughly triangular-shaped gravity "Low" which is approximately defined by the enclosing eleven milligal contour, and extends on both sides of Washpool Creek. It covers an area of approximately two and a half square miles. For convenience this anomaly is referred to as "Blair Athol Low". The lowest Bouguer values (= 9.44 milligals) occurs near the centre of the "Blair Athol Low".

Northeast to north-northeast running contours with steep gravity gradients mark the margin of the "Blair Athol Low" to the northwest, over a distance of approximately

three miles. On the southern margin of the "Blair Athol Low" the trend of the contours is generally easterly and the gradients are significantly less steep than on the northwestern margin of the "Blair Athol Low".

There is no uniform trend noticeable in the contours which terminate the "Blair Athol Low" to the northeast, east and southeast. In fact the ten-and-a-half and the eleven milligal contours run due east over a certain distance along the northeastern limb of the "Blair Athol Low" and then swing rather abruptly from east to almost due south in the area of M.L.69 and 68 (see Plate 2). Immediately north of the townsite of Blair Athol contours swing again east for a distance of approximately one mile parallel to the northern boundary of M.L.5 and POR 269. Proceeding further east into the area of M.L.56 it is found that the trend of the gravity contours is again mainly south.

(b) Two significant gravity "Highs" protrude into the eastern and southeastern margin of the "Blair Athol Low". One of these is a tongue-like anomaly feature, which centres at some distance north of the townsite and immediately northeast of Blair Athol No.2 Colliery where a closure occurs in the twelve milligal contour.

The other, a more isolated "High", is indicated by a maximum Bouguer anomaly of 12.83 milligals south of the railway line to Clermont and is centred immediately southeast of Bath Creek. A horseshoe-shaped zone of low gravity intensity encloses this "High" to the east, south and southwest.

(c) Outwards from the "Blair Athol Low" Bouguer anomalies increase to maximum values. A closure in the twelve-and-a-half milligal contour occurs southwest of the Blair Athol Open-cut Collieries Ltd. workings west of Washpool Creek. East of the "Blair Athol Low" the Bouguer anomaly exceeds fourteen milligals on a northeast striking feature which occurs east and roughly parallel to the boundary of the parish of Blair Athol with the parish of Apsley. This difference in gravity intensity between the western and the eastern side of the "Blair Athol Low" indicates the existence of a regional gravity gradient, which is superimposed on the more local anomaly feature. This gradient amounts to approximately one and a half milligals of gravity variation over a horizontal distance of three miles.

(d) A relatively weak gravity "Low" of somewhat irregular shape extends north from the "Blair Athol Low" into the area, which is approximately a half mile distance west and northwest from the old Newcastle Extended shaft. This "Low" deepens near the Drummond Range into a closed minimum with lowest Bouguer values (= 10.75 and 10.81 milligals)

established at two stations.

(e) A strong regional gravity gradient, which is negative to the northwest, finds its expression in roughly parallel gravity contours north of the Drummond Range. For convenience the anomaly pattern north of the Drummond Range is shown with this regional gradient removed on Plate 4.

Generally the contour pattern of the area north of the Drummond Range is one of irregular alignment of alternating gravity "Highs" and "Lows", except for the western anomaly trend, where Bouguer values of relatively low intensity prevail along a distinct zone of north-northwest strike.

5. ANALYSIS OF RESULTS.

In principle the evaluation of the gravity anomalies observed 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 bores drilled for the purpose of 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 under an overburden of younger rocks. It is likewise obvious that in a fringe zone around the coal basin gravity values are relatively high near the outcrops of older Palaeozoic rocks.

A. ROCK DENSITIES.

The densities of the rocks, which occur in the Blair Athol area, were determined by several authors over a period of more than twenty years. The results of these density tests are tabulated in Table 1 (Page 7).

The table shows that the density of some of the basalt may be as high as 3.09. However, the later testing of several cores of unweathered basalt obtained from bore N.22 near the eastern boundary of the coalfield shows that its density varies between fairly wide limits. The average density is probably substantially lower than the maximum value. A mean density of 2.79 resulted from the testing of the specimens of basalt collected from the above mentioned bore 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 than this average and may not differ greatly from the average density of the basement rocks (Clermont Slates).

It was mentioned earlier that the gravity anomaly pattern does not appear to be influenced to any appreciable extent by the distribution of the basalt. The reason for this is presumably due to the following factors:-

(i) As a whole the basalt is presumably of relatively slight thickness as earlier suggested by

J. H. Reid (Reid, 1936):

(ii) Much of the basalt is altered by weathering which has caused a higher porosity and lower density to prevail over major portions of the basalt.

(iii) Vesicular development of parts of the lava flows during the initial stage of the deposition of the basalt is possible, and would result in relatively low density.

Second highest rock density in Table 1 is that of the Clermont slate formation; a mean density of 2.65 was obtained from the testing of several specimens.

TABLE 1.

ROCK DENSITIES
BLAIR ATHOL COALFIELD.

East-central Queensland.

Type	Age/Locality	Density	Year when density was determined.
Basalt	Tertiary/Newcastle Extended Shaft	3.09 *	1939
"	Tertiary/Bore N22	2.79 *	1959
Clermont Slate	Silurian (?)	2.84	1939
"	"	2.65 *	1939
Shale	Permian	2.38	1939
Sandstone	Permian	2.23 *	1939
Overburden, including shales, Sandstone and grits.	Post-Permian	2.20 *	1958
Coal	Permian	1.39	1936
"	"	1.33	1939
"	"	1.28 *	1958
Soot	-	1.05	1939
Soil, black and sandy.	Recent	1.4 to 2.0	1939

Note:- Density figures shown with asterisk are mean values obtained from the testing of several specimens. Densities shown were determined by the following authors -

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

The analysis of the correlated gravity and geological cross-sections (described later) indicates that a density of 2.65 to 2.70 is most likely representative for the Clermont slate formation as a whole. One specimen listed in Table 1 has an appreciably higher density (= 2.84) than the mean Clermont

shale density. This indicates the possibility of lateral variations in the density of the rocks, which 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 which would be superimposed on the other effects.

Lowest among the rock densities listed is that of soot (= 1.05) and Blair Athol coal (= 1.33). Soot occurs only to a limited extent within or overlying the coal seams and its presence would have little effect on the density of the coal seams as a whole.

Density data available from Permian beds other than coal, which form the greater portion of the sediments down to the basement of the coal basin include shale (density = 2.38) and various types of sandstones (mean density = 2.23). Specimens of conglomerates, which occur at the base of the coal measures were not available for density tests. The mean density of Permian conglomeratic beds can be assumed to be in the order of 2.5. The overall (bulk) density of the Permian sediments - other than coal - including sandstones, shales and conglomerates is assumed to be approximately 2.4 grammes/ccm.

From the analysis of the gravity variation along the known cross-section A - A, the overall density of the coal measures, including the coals which fill the Blair Athol basin, appears to vary within limits of 2.1 to 2.3 grammes/ccm. This finding agrees reasonably well with the results of the density determinations mentioned above and can be illustrated as follows:-

> An assumed column, including a total thickness of 800 feet of sediments, composed of seven hundred feet of clastic sediments (density = 2.4) and one hundred feet of solid coal (density = 1.3), has an average density of 2.3 grammes/ccm. In contrast, a similar column of 400 feet total length containing three hundred feet of clastic sediments and one hundred feet of coal, assuming same densities as before, has a mean density of approximately 2.1 grammes/ccm.

B. INTERPRETATION PRINCIPLES.

Basically the geophysical problem is to determine from the gravity data the distribution of the coal measures whose average density ranges from approximately 2.1 to 2.4 (depending on the relative amount of coal present) overlying a basement of Clermont slates whose average density is 2.65 to 2.70. 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 on 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 Bouguer anomaly established near the outcrops of the Clermont Slates (approximately 12.5 milligals) and the minimum anomaly (= 9.44 milligals) observed near the centre of the "Blair Athol Low".

The thickness of the coal measures corresponding to a gravity anomaly of three milligals is set out in Table No.2 for a range of assumed density contrasts between the coal measures and the underlying Clermont slates.

TABLE 2.

THEORETICAL THICKNESS OF COAL MEASURES.

Density Difference between Coal Measures and basement (Clermont Slates).	Total thickness of Coal Measures	Maximum Gravity Variation.
0.6 grammes/ccm.	400 feet	3 milligals
0.5 "	500 (approx "	"
0.4 "	600 "	"
0.3 "	800 "	"

The range of probable thickness in Table 2 agrees reasonably well at least in order of magnitude with the known geology of the Blair Athol coalfield, as is further shown by the following analysis of cross-sections.

C. 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 results of the gravity investigation in relation to geology. The sections referred to are shown on Plate 5 and the horizontal projection of the section lines appears on Plate 3.

For the purpose of the analysis Bouguer anomaly curves are shown superimposed on geological data obtained from drilling, shaft sinking and from known outcrops. The probable densities of the formations, which occur in the section, were computed and the probable depth to the basement was determined from the observed anomaly data. Where possible the position of the basement was plotted by using the information on basement depth obtained by drilling.

In order to prepare the gravity curves for precise analysis it was necessary to eliminate the regional gradient, which amounts to one and a half milligals gravity variation over approximately three miles and is negative to the northwest (vide page 6).

(i) Cross Section A-B-C.

Section A-B-C runs east-southeast from a point, which is a quarter of a mile west-northwest of the Newcastle West shaft, towards bore No.3 and then turns

south towards bore No.6. From the western end of the section 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 contained in the "Big" seam and partly by an increase in the thickness of the Permian beds as a whole. At the Newcastle West shaft basement was reached at 409 feet. According to gravity data the basement most likely deepens further east of the shaft by another one hundred feet. This interpretation is supported by the section revealed by bore No. J17, in which the surface of the "Big" seam was encountered approximately 70 feet deeper than in the Newcastle West shaft.

Further eastwards a gradual rise in gravity intensity suggests a corresponding progressive rise of the basement floor towards Newcastle Colliery main shaft and towards the bores No. 3 and No.2. At bore No.2 basement was struck at a depth of 142 feet, indicating that it is near the eastern margin of the basin. The "Big" seam near the margin of the coal occurrence is split into several thin seams containing coal, carbonaceous shale and shale with coal bands (Reid, 1948). To the immediate west of bore No.3 the gravity gradient shows a local steepening which is most likely caused by a rapid thinning of the coal contained in the "Big" seam toward the eastern margin of the basin and the transition from solid black coal to inferior coal and carbonaceous shale.

The striking of bedrock in Bore 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 Bores 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-southwestwards from a major ridge of basement rocks which is aligned mainly eastwards and east-southeastwards. According to gravity data the main ridge extends easterly from the Newcastle Extended shaft over a distance of roughly two miles. This ridge of shallow basement evidently lies to the east of the main Blair Athol Coal basin; no commercial coal seam was intersected in the Newcastle Extended shaft and none of the bores (No. 1 to No. 5) drilled in the area outlined by the gravity "High" encountered coal of appreciable thickness.

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

(ii) Cross Section B'-B-C-D.

Section B'-B-C-D shows the geological information obtained from the bores sunk in 1947 (No.1 to No.8) plotted at natural scale of 1 inch equals 660 feet, in relation to the Bouguer anomalies. This cross-section runs south from the bore No.5 to the bore No.6 and then

swings east towards bore No.8. For convenience the geological section is also plotted with the vertical scale exaggerated to 66 feet to one inch, so that the stratigraphic detail is emphasised.

The depth to the basement is established by two bores, No.2 and No.7, where Clermont slates were reached at depths of 142 feet and 577 feet respectively. Certain allowances were made in the anomaly curve for the regional gradient and for a local gravity anomaly, which might be caused by the presence of basalt in bore No.8.

The Bouguer anomaly is relatively high over the section between bore No.1 and bore No.5 corresponding to shallow basement and the absence of any appreciable thickness of relatively light coal. It reaches a maximum at bore No.2 where basement is shallowest and also rises to a high value at the extreme eastern end of the section where presumably basement is also very shallow. The Bouguer anomaly decreases rapidly in passing from Bore No.2 to Bores Nos. 6 and 7, due to the presence of a large thickness of the "Big" seam and a rapid deepening of the basement. Further east gravity increases due to a progressive rise in basement and a decrease in the amount of coal present in the section. The geological section at bore 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.

(iii) Cross Section C-E-F.

Profile C-E-F is a southerly extension of the Section A-B-C and runs southwest from bore No.6 towards Bluff Colliery. It then swings due south across the southern margin of the coal basin. The anomaly curve - with the regional gravity gradient removed - indicates most likely a flat lying basement at a depth approximately 600 feet between No.6 bore and the Eldorada Shaft. According to gravity data the bedrock commences to rise to the south from a point at one eighth of a mile distance south of Eldorada shaft. Associated with this rise of the basement the "Big" seam gradually thins towards Bluff Colliery, where forty feet of coal is reported. Near the southern end of section CEF coal finally wedges out. Owing to the absence of gravity data on the southernmost portion of the section line, the gravity anomaly was projected from stations occupied at a certain distance further east into the C-E-F section. The very gradual rise in gravity intensity to the south indicates a similar gradual rise in basement.

No depth control is available from drilling to the basement on the C-E-F section. The position of the bedrock is computed solely from gravity data by assuming densities for the bedrock (= 2.65) and for the total thickness of the Permian sediments (=2.33).

(iv) Cross Section H-G.

Section H-G runs northwest from Blair Athol Coal and Timber Company's workings across the main basin structure through Imbel shaft and half way between the bores O 16, O 17, N 15, N 16, M 14 and M 15.

The Bouguer anomaly curve, after corrections made for the regional gravity effect, reaches a minimum immediately northwest of bore N 16, where basement is presumably deepest. Further west the gravity intensity increases gradually with an appreciable steepening in the gradient between the bores M 14 and M 15 as the western margin of the basin is approached.

From the analysis of section H-G it is obvious that the minimum gravity deficiency which occurs on this particular portion of the coal basin can not be explained by variations in the thickness of the coal contained in the "Big" seam. In fact the thickness of the coal, as drilling results show, remains very much the same between the Blair Athol Coal and Timber Company's workings and bore M 15. The "Big" seam is approximately one hundred feet thick over a distance of one and a half miles across the whole width of the coal basin.

On the other hand the amplitude of the gravity "Low" near bore N 16 indicates a total maximum thickness of Permian sediments of roughly eight hundred feet, when assuming, as before, a density of 2.65 as representing the basement rocks and 2.33 for the Permian sediments. There appears to be a local depression in the basement floor between bores N 15 and N 16, and the deepest portion of the Blair Athol basin is likely to exist under the area which is approximately outlined by the 9½ milligal contour of the gravity anomaly plan.

The steep gravity gradient between bores M 15 and M 14 is due to the combined effects of the "Big" seam cutting out and a steep rise in the basement floor. A similar steep gradient is present at the western end of Section A-B-C. An inspection of the gravity contour plan, plate 3, shows that this steep gradient persists throughout the north-western margin of the Blair Athol basin at least between traverses I and O. Over this length 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 southeast of Bath Creek. The isolated gravity "High" which was shown by gravity readings on a limited number of stations spread out over this particular area, would require a denser coverage to delineate it accurately. In addition, no information with regard to the depth to the basement rocks was available at the time when this report was written. An overall inspection 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", which encloses the "High" to the east, south and southwest. Near the centre of the gravity maximum the coal contained 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 likely underlain by basement rocks at shallow depth.

(v) Assessment of Coal Reserves.

(a) One of the main objectives of the gravity

survey was to prospect for additional coal deposits which might be concealed beneath Permian Sediments and/or Tertiary basalt for the area to the north 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" which extends west and northwest of the Newcastle Extended shaft and deepens near the Drummond Range to a closed minimum anomaly. This "Low" most likely indicates a depression in the basement floor containing Permian sediments. In area this "Low" is less than one sixth the size of the "Blair Athol" low and the maximum anomaly is approximately 0.5 milligals compared with 3 milligals over the "Blair Athol" low. An anomaly of 0.5 milligals can be explained by a basement depression 400 feet deep filled with sediments that differ from the basement in density by 0.20 gm/cc. From the point of view of additional coal reserves this looks most unpromising but nevertheless the possibility of coal being present in significant quantities cannot be ruled out entirely and a test bore hole is warranted.

Results obtained by drilling the bores No.7 to No.17 north of the Drummond Range in the Parish of Miclere (see Plate No.2) indicate variations to occur in the depth to the 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 that lower gravity anomalies are related to a lower position of the bedrock.

In addition the irregular alignment of relatively small gravity "Highs" and "Lows" in the area north of the Drummond Range could be explained by the existence of horizontal density variations of the basement complex. Density variations of sufficient magnitude can give rise to gravity anomaly variations, which would appear superimposed on the anomalies related to sediments of varying thickness, deposited upon an uneven basement floor.

In the Blair Athol basin there is a close correlation between the gravity values and the distribution of coal. Four subdivisions can be recognized in the coal bearing area. These divisions, which are shown on Plate No.6 and numbered (i) to (iv) are briefly described as follows:-

(i) The main coal deposit is defined by a gravity contour which runs approximately between the ten and a half and the eleven milligal line. In a general manner this line corresponds to the sixty feet coal isopach, obtained from the interpolation of drilling data.

(ii) A southeastern extension of the main coal basin is expressed by the horseshoe-shaped gravity "Low", which surrounds the

isolated gravity maximum south of Bath Creek.

(iii) An area of marginal coal development north, northeast and east of the main coal occurrence has been fairly accurately defined by the results of the 1959 gravimeter survey. The gravity contours based on the data obtained by the recent survey confirm and supplement the fixation of the coal boundary mainly to the north and east.

(iv) The southern margin of gradually thinning coal coincides approximately with the southern limb of the Blair Athol gravity "Low", but the gravity information south of the main coal basin is not sufficient to establish the boundary of commercial coal development in this particular section of the coalfield with reasonable certainty.

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 containing commercial coal are not rated high, nevertheless it is considered that a test bore is warranted.

The gravity data over the Blair Athol deposit has given useful information on the basement configuration and has assisted in clarifying 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 to be little doubt that if coal deposits similar to those at Blair Athol exist under cover of superficial deposits elsewhere in this general area they can be found by a gravity survey.

7. REFERENCES.

-	1953	Coal in Queensland. Fifth Empire Mining and Metallurgical Congress Australia and New Zealand Publications - Volume VI, Melbourne.
DOOLEY, J.C., McCARTHY, E, KEATING, W.D., MADDERN, C.A. and WILLIAMS, L.W.,	1959	Pendulum Measurements of Gravity in Australia. Bur. Min. Res. Geol. and Geophys. Bull. No. 46. In Press.
BRYAN, W.H. and JONES, O.A.	1945	The Geological History of Queensland. A Stratigraphic outline. University of Queensland, Dept. Geology Papers - Volume 2, No. 12, Brisbane.

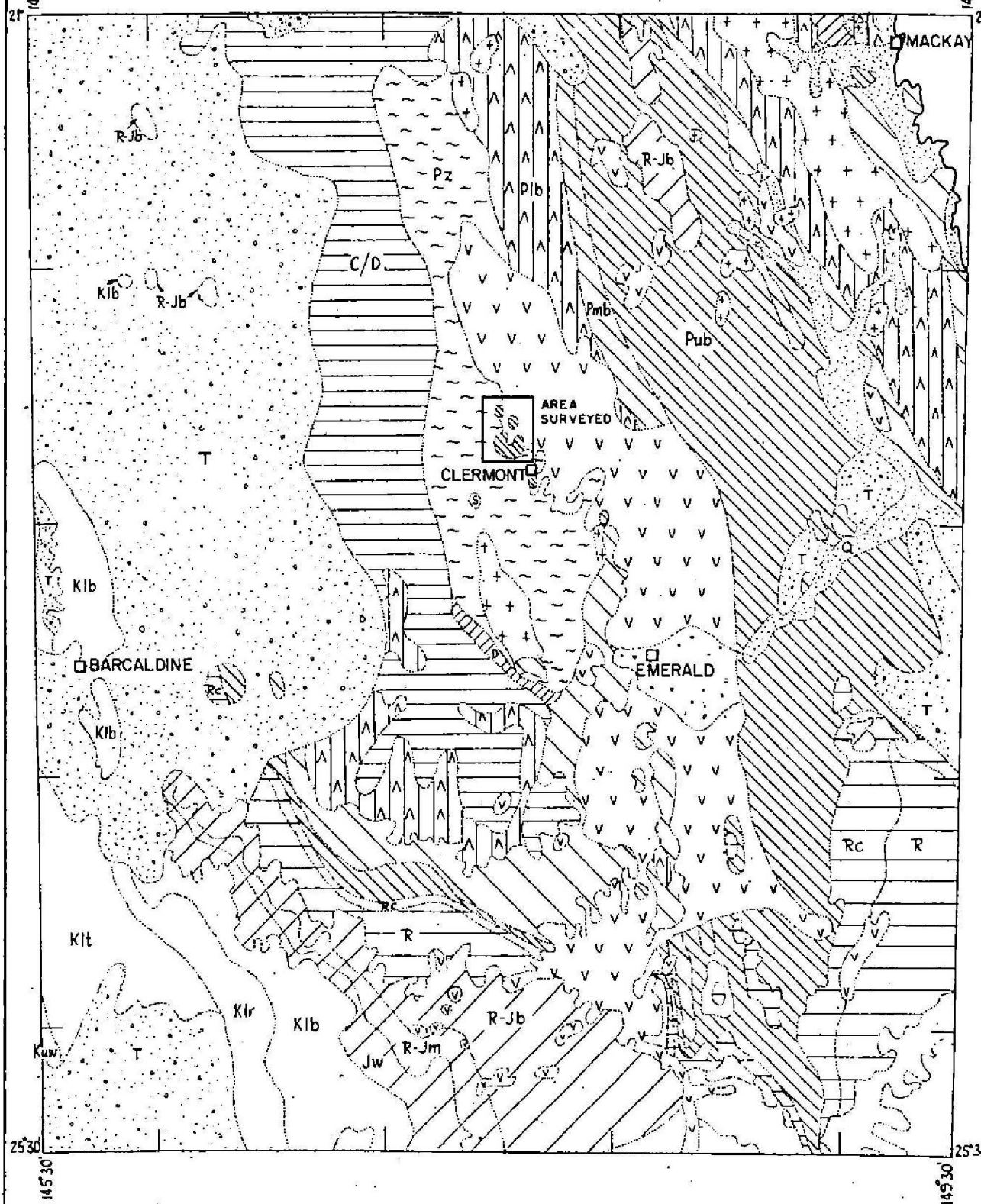
McIVER, F., KNIGHT, C.L. and SPRATT, R.N. 1958 Blair Athol Coalfield, Queensland Preliminary Report, April - July 1958 (unpublished) Cons. Zinc Proprietary Limited, Exploration Division, Melbourne.

RAYNER, J.M. and THYER, R.F. 1939 Geophysical Survey Blair Athol Coalfield, Queensland. Aerial, Geol. and Geophysical Survey of Northern Australia, Report for period ended 31st December, 1939, Plate 8, Canberra.

REID, J.H. 1936 Blair Athol Coalfield. Queensland Government Mining Journal October, 1936, Brisbane.

REID, J.H. 1948 Blair Athol Coalfield Drilling. A Record of the 1947 Boring Campaign, Queensland Government Mining Journal March, 1948, Brisbane.

PLATE I



LEGEND

Q — Quaternary	V v V — Basalt
T — Tertiary	+ + + — Granite
K — Cretaceous	S — Serpentine
Jurassic and Jurassic/Triassic	Kuw — Winton Formation
R — Triassic	Klt — Tambo Formation
Upper Bowen Coal Measures	Klr — Roma Formation
Middle Bowen Group	Klb — Blythdale Formation
Lower Bowen Volcanics	Jw — Walloon Formation
C/D — Carboniferous/Devonian	R-Jm — Marburg Formation
D — Devonian	R-Jb — Bundoma Group
Pz — Lower Palaeozoic (Clermont Shale)	Rc — Clematis Sandstone

DETAILED GRAVITY SURVEY (1959)

BLAIR ATHOL, QUEENSLAND

REGIONAL GEOLOGY

SCALE IN MILES

40 0 40 80

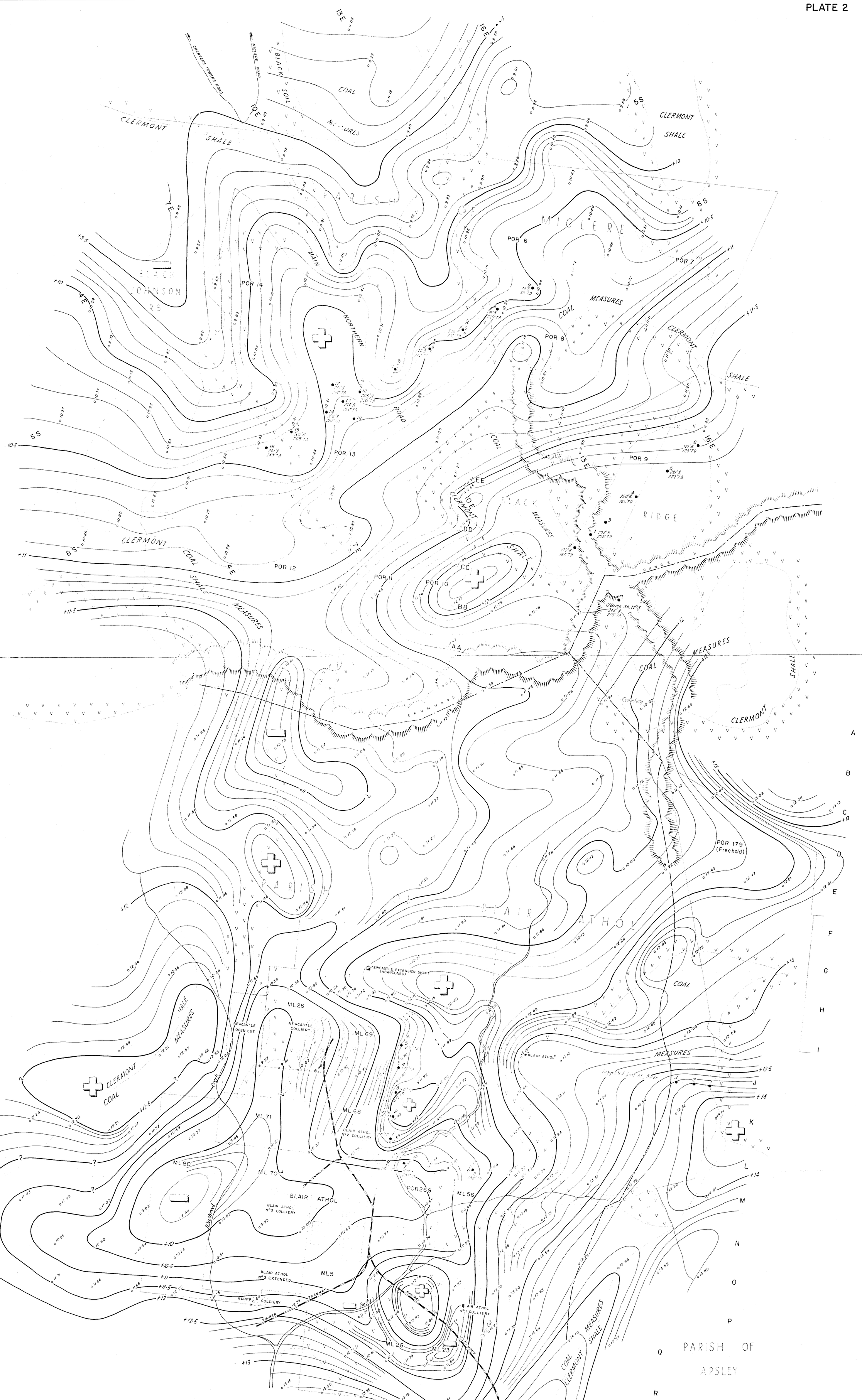
Reference: Geological Map of Queensland: 1953

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics.

G 325-5

TO ACCOMPANY RECORDS 1959, No. 143

PLATE 2



LOCATION

REFERENCE TO AUSTRALIAN NATIONAL 4 MILE MAP SERIES

MAP DATA

BASE MAP FROM GEOLOGICAL AND DRILLING PLAN, BLACK RIDGE AND APSLEY CREEK, A.G.S.N.A., 1936, QUEENSLAND REPORT

QUEENSLAND GOVERNMENT MINING JOURNAL VOL 37, 1936, VOL 47, 1946 AND VOL 49, 1948

G Rummery
GEOPHYSICIST

DETAILED GRAVITY SURVEY (1959)

BLAIR ATHOL, QUEENSLAND

BOUGUER ANOMALIES AND GEOLOGY

½ 0 ½ 1 ½

SCALE IN MILES

LEGEND

- GRAVITY STATION
- 5S STATION NUMBER
- 40·52 BOUGUER ANOMALY IN MILLIGALS
- ANOMALY ISOGAMS IN MILLIGALS
- HIGH ANOMALY
- LOW ANOMALY
- MINING OPERATIONS
- COAL EXPLORATION BORE
- GEOLOGICAL BOUNDARY
- BASALT
- PROBABLE LIMIT OF COMMERCIAL COAL (after Reid)
- 577'8 DEPTH TO BASEMENT
- 592'TD TOTAL DEPTH
- PARISH BOUNDARY

EXPLANATION

RELATIVE BOUGUER ANOMALIES ARE BASED ON OBSERVED GRAVITY VALUE OF 979,776·4 MILLIGALS AT B.M.R. N°5C PENDULUM STATION, CLERMONT.

FOR THE CALCULATION OF BOUGUER ANOMALIES 2·2 GR/CCM. HAS BEEN TAKEN AS AN AVERAGE ROCK DENSITY.

GRAVITY FIELD SURVEYS BY GEOPHYSICAL SECTION, B.M.R.

ELEVATION DATUM – QUEENSLAND STATE DATUM (M.S.L.)

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

G 325-4

TO ACCOMPANY RECORDS 1959, No. 143

PLATE 3

NEWCASTLE EXTENDED (NO COMMERCIAL COAL)

NEWCASTLE WEST SHAFT

BLAIR ATHOL OPEN CUT COLLIERIES LTD

NEWCASTLE COLLIERY MAIN SHAFT

ML26

ML69

ML71

ML68

HOSPITAL

BLAIR ATHOL No 2 COLLIERY

HOMESTEAD WELL

GRAHAM'S ROAD

HOPE SHAFT

BLAIR ATHOL No 3 COLLIERY

JEFFREY STREET

CLANCY JONES WINDSOR STREET

BLAIR ATHOL RAILWAY STN.

POR 269

ML 56

HARDACRE STREET

RISEN STREET

DERRET STREET

IMBEL STREET

BLAIR STREET

HETHERINGTON ST.

IMBEL SHAFT

ELDORADO SHAFT

To Clermont Towns 100 CHAINS

AIR SHAFT

SCHOOL

Approx. boundary of 10' minimum coal thickness

COAL CREEK

BLAIR ATHOL No 3 EXTENDED SHAFT

Old Timber Tramway

ML70

ML80

ML5

BATH CREEK

BLUFF COLLIERY

Tunnel

BLAIR ATHOL COAL & TIMBER CO.

BLAIR ATHOL No 1 COLLIERY

SPOIL 12.27 DUMP

To Bernborough

The Washpool

Rail Coal Dispatch

ML 28

ML 23

To Clermont

Approx. Boundaries of Coal

SCALE OF CHAINS 10 0 10 20 30 40 50

Shaft

Gravity Station

Bore Hole & Gravity Station

Bore Hole

Bouguer Anomalies in Milligals 13-7

Contours 10-0

High Anomaly

Low Anomaly

Analysed Cross Section A — B

DETAILED GRAVITY SURVEY (1959)

BLAIR ATHOL COALFIELD, QLD.

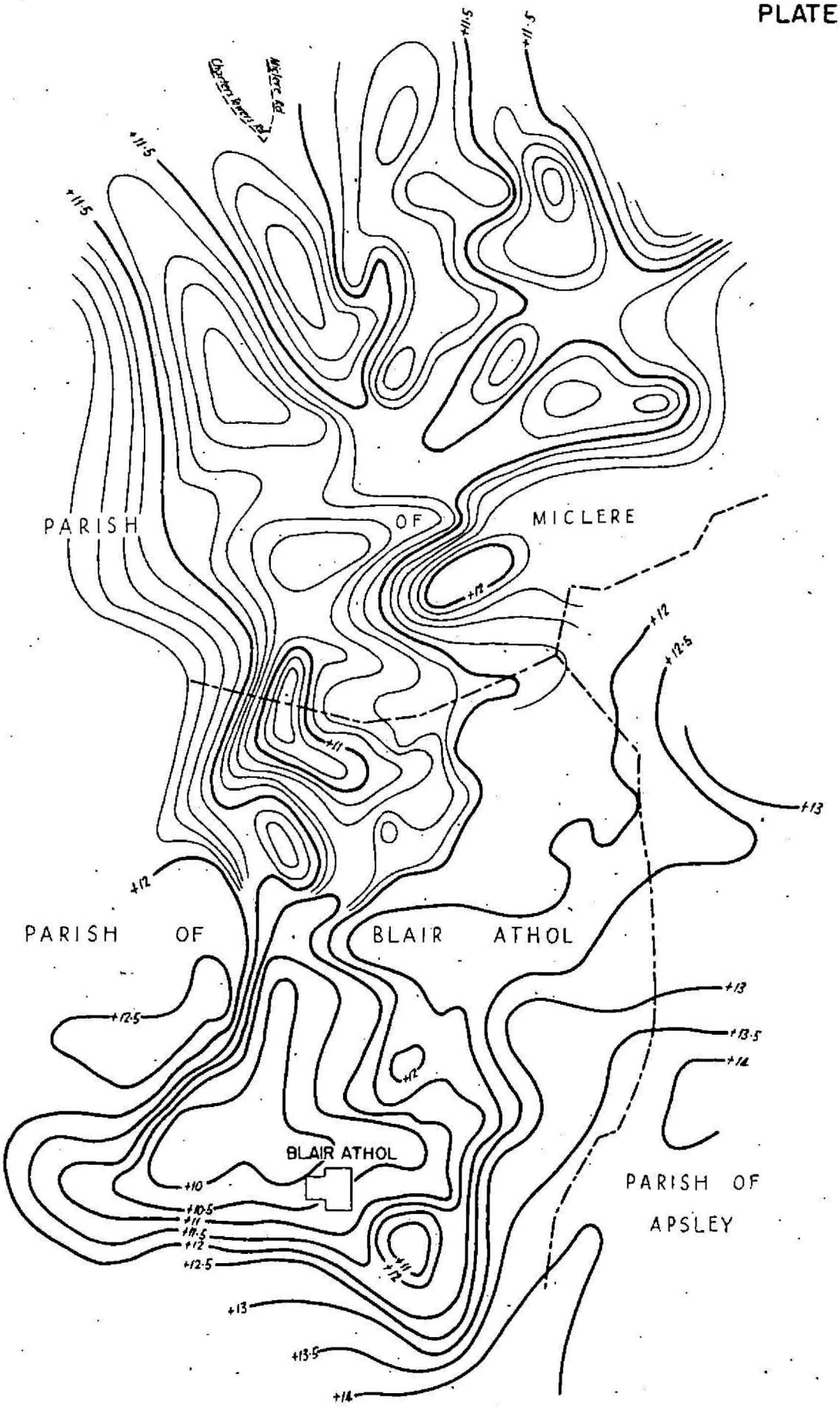
BOUGUER ANOMALIES

B. Neumann
GEOPHYSICIST

G 325-3 V

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS
TO ACCOMPANY RECORDS 1959 NO 143

PLATE 4



LEGEND

GRAVITY HIGH ANOMALY

" LOW "

PARISH BOUNDARY

C. Newman

GEOPHYSICIST

DETAILED GRAVITY SURVEY (1959)

BLAIR ATHOL, QUEENSLAND

BOUGUER ANOMALIES WITH MAIN REGIONAL GRADIENT REMOVED

SCALE IN MILES

1 0 2

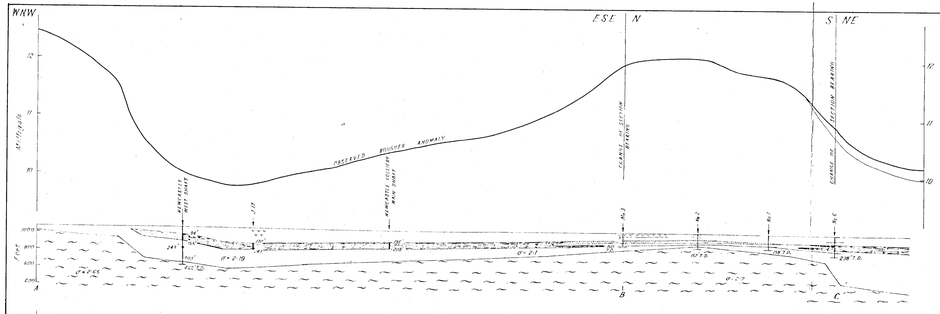
CONTOUR INTERVALS AS SHOWN

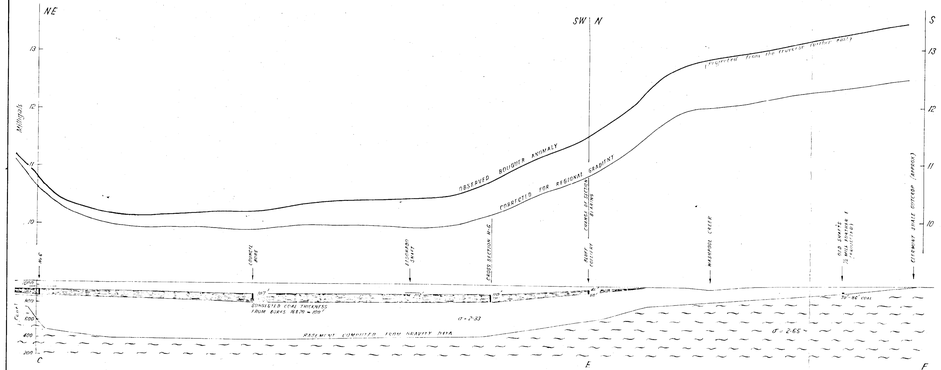
TO ACCOMPANY RECORDS 1959, No. 143

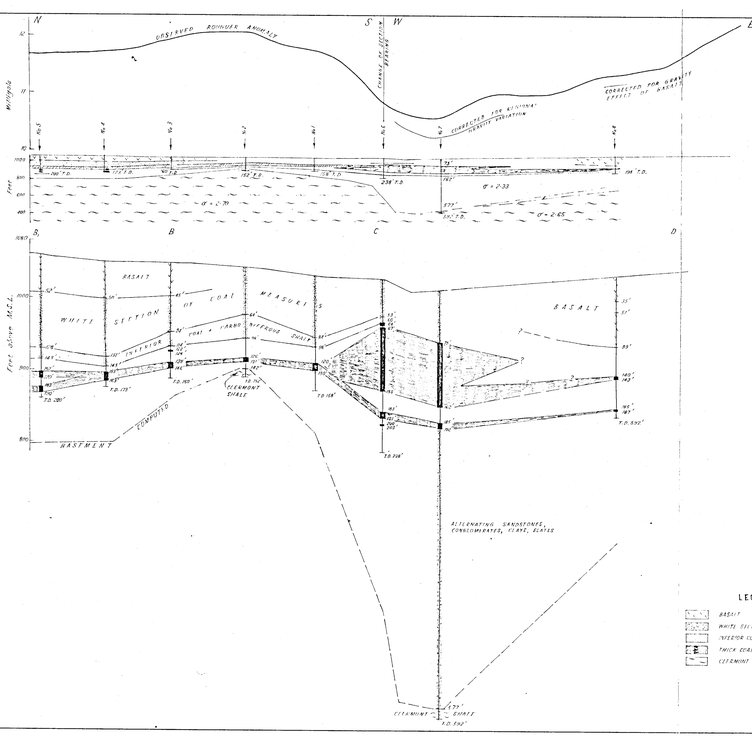
Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

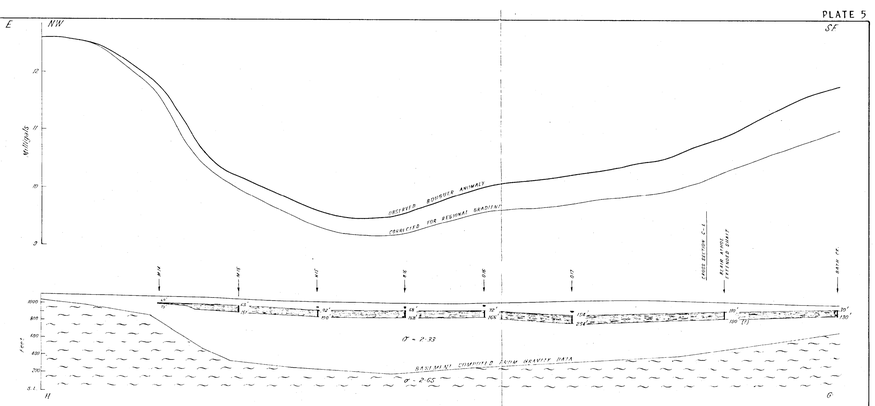
G 325-7

PLATE 5









LEGEND

- BASALT
- WHITE SECTION IN COAL MEASURES
- INTERIOR COAL AND FERRUGINOUS SHALE
- THICK COAL
- CLEMMONT SLATE (BASEMENT ROCK)

G. Waterhouse
GEOPHYSICIST

DETAILED GRAVITY SURVEY (1959)
BLAIR ATHOL, QUEENSLAND
CORRELATED CROSS SECTIONS OF BOUGUER ANOMALIES AND GEOLOGY

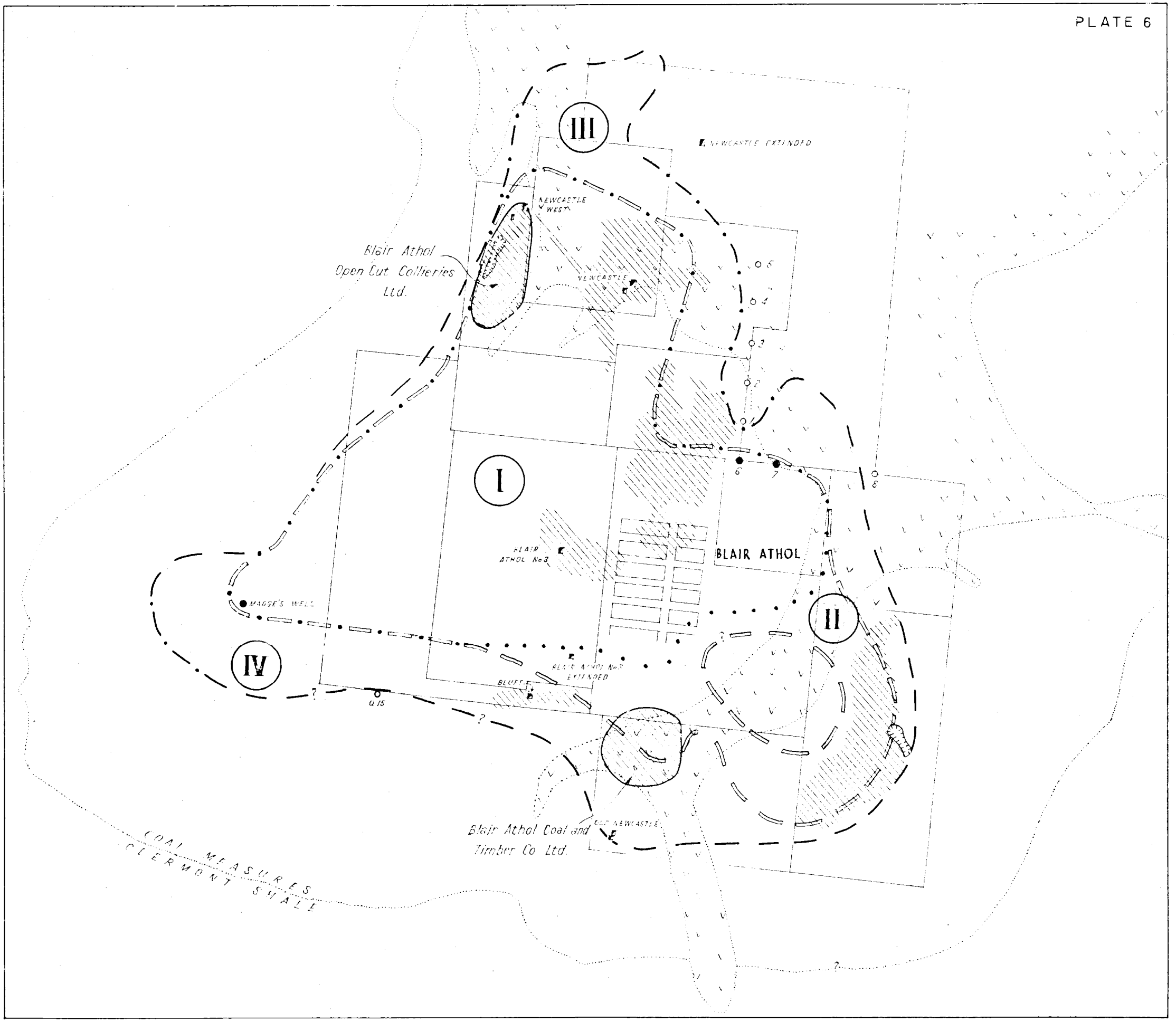
HORIZONTAL SCALE IN FEET

600 0 600 1200 1800 2400 3000 3600

VERTICAL SCALES AS SHOWN

TO ACCOMPANY RECORDS 1959, No. 165

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics G 325-6V



LEGEND

- 60 FEET ISOPACH
- PROBABLE BOUNDARY OF THICK AND/OR COMMERCIAL COAL
- BOUNDARY OF THICK COAL (A.G.G.S.N.A., 1939)
- " * MAIN COAL BASIN (B.M.R. GRAVITY SVY 1959)
- GEOLOGICAL BOUNDARY (I.G. WHITCHER, 1959)
- BASALT
- COLLIERY WORKINGS (IN OPERATION / ABANDONED)
- OPEN CUT "
- EXPLORATION BORE (COAL OF APPRECIABLE THICKNESS)
- " " (NO COMMERCIAL COAL)
- SHAFT

G. Neumann
GEOPHYSICIST

DETAILED GRAVITY SURVEY (1959)
BLAIR ATHOL COALFIELD, QLD.

DISTRIBUTION OF COAL RESERVES

SCALE IN CHAINS
30 0 30 60 90

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