Chief Geologist.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF SUPPLY AND DEVELOPMENT

*J. K. JENSEN, SECRETARY*

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

*H. G. RAGGATT, DIRECTOR*

REPORT No.1

(GEOPHYSICAL REPORT No. 1)

PRELIMINARY REPORT

*ON THE*

# GEOPHYSICAL SURVEY OF THE COLLIE COAL BASIN

*N. G. CHAMBERLAIN, GEOPHYSICIST*



ISSUED UNDER THE AUTHORITY OF SENATOR THE HONOURABLE J. ARMSTRONG, MINISTER FOR SUPPLY AND DEVELOPMENT.

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## C O N T E N T S



## LIST OF PLATES



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# GEOPHYSICAL SURVEY OF THE COLLIE COAL BASIN.

## ABSTRACT.

Collie is the only developed coalfield in Western Australia. In 1946 production amounted to 642,286 tons which represented 80 per cent of the coal consumed in Western Australia. The Collie coal area is largely a concealed field, the coal measures and the surrounding granite being almost wholly covered by laterite and Pleistocene and Recent alluvial and lake deposits. Also only a limited amount of drilling has been done. Because of those factors the extent of the coalfield could not be determined by normal geological methods and there was only incomplete information concerning the thickness of the coal measures and of the distribution of coal seams within the measures. Moreover, inadequate information was available to enable a drilling campaign to be planned to the best advantage. However, the coal measures are lower in density than the granitic rocks forming the rim rock and probably the bed rock of the basin, with the result that the coal basin is an area of relatively low gravity values. By means of a comprehensive gravimeter survey (see Plate 1) it was possible to determine the boundary of the basin, its general configuration and the depth (thickness) of the sediments overlaying the basement. By determining these factors it has been possible to define those areas where there is sufficient thickness of sediments to enable drilling to be carried out with a reasonable expectation of proving additional preserves of coal. On the basis of the geophysical results it is recommended that holes be drilled down to the basement at certain selected sites where such holes would be of most value in providing control data for a fuller interpretation of the gravity results and in giving a general indication of the additional coal resources of the Collie coalfield.

## I. INTRODUCTION.

The township of Collie is situated in the south-west portion of Western Australia and is 124 miles by rail from Perth and 41 miles from the nearest seaport, Bunbury.

Coal was first discovered at Collie in 1883 and development of the coalfield has been in progress since 1900. Collie is the only developed coalfield in Western Australia and at the present time coal is being produced from six collieries and two open-cuts. In 1946 production amounted to 642,286 tons, which represented 80 per cent. of the total coal consumed in Western Australia, including coal required for bunkering ships.

Between June 1946 and April 1947 a comprehensive geological and geophysical survey of the Collie coalfield was carried out under joint Commonwealth and State auspices. The Geological Survey of Western Australia was responsible for the geological work and the Geophysical Section of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics for the geophysical work. Although several reports on the coalfield have previously been prepared, no complete survey similar to that recently carried out has previously been made.

Also, the only prospecting carried out on the coalfield has been mainly confined to areas adjacent to the existing collieries and all the drilling done to date has been shallow. As a result there has been a lack of information concerning the extent of the coalfield, particularly towards the south-east.

The Collie Coal Basin is situated in a depression at an average elevation of about 700 feet above sea level. Due to recent erosion the main surface features are laterite hills and ridges separated by sandy flats with numerous swamps and creeks. Most of the area is heavily timbered. The annual rainfall is 40 inches and the area is drained by the Collie River, the South and East branches of which traverse the Coal Basin.

It is desired to acknowledge the assistance given by the Government Geologist of Western Australia and to express appreciation of the ready co-operation, which was extended to the writer, by officers of the Western Australian Geological Survey, throughout the course of the survey.

The writer is also indebted to other officers of the Bureau for help given both in the field and during the preparation of this report, and to Mr. J. Hogg of the Western Mining Corporation for his work as surveyor during the greater part of the survey.

## II. GEOLOGY.

The geology of the Collie Coal Basin has been described by Wilson in the "Report of the State Mining Engineer 1944". The Collie coal measures are of Permian age and have been laid down in a basin in Pre-Cambrian rocks which consist chiefly of granite. Laterite, alluvial and lake deposits of Pleistocene and Recent age overlie the coal measures and adjacent Pre-Cambrian to such an extent that, from surface indications alone, only a very incomplete definition of the granite rim of the basin, and hence of the full extent of the coal measures, is possible.

## III. GRAVITY METHOD & APPLICABILITY TO PROBLEM.

In the geophysical survey of the Collie Coal Basin the gravity method was employed. In general terms, a gravity survey consists of measuring the force of gravity at points distributed over an area. The gravitational attraction of the material underlying the earth's surface is dependent on its density, with the result that variations in density in a geological section will produce corresponding variations in the gravitational force observed over that section. Consequently, the variations in gravity over an area may be interpreted in terms of the distribution of sub-surface masses.

The variations in gravity usually encountered in this type of survey are extremely small and the instrument used must be sensitive enough to measure such small variations of the order of less than one milligal, that is, less than one part in a million of the total gravitational force. The instrument used in the Collie survey was a Humble-Truman Gravity Meter, which, under the most careful conditions of operation, enabled gravity values to be determined with an accuracy of $\pm$ 0.2 milligals.

Owing to instability and drift of the zero which are inherent features of the instrument, it was necessary to carry out the readings at each gravity station at least twice to ensure reliable results. The Humble-Truman Gravity Meter has now been superseded by greatly improved meters which have higher sensitivity and absence of drift and are also lighter, more portable and easier to operate. Meters of the new type are now being used by the Bureau but at the time of commencing the Collie survey the Humble-Truman instrument was the only one available.

The applicability of the gravity method to the problem of mapping the Collie Coal Basin depends on the fact that the coal measures are lighter than the granitic rocks forming the bed and rim rock of the basin. The density difference as known from laboratory tests is approximately 0.5. As a result of this density difference the coal basin is an area of low gravity values or of negative gravity anomaly. The gravity variations associated with the coal basin were investigated for the purpose of, (1) delimiting the boundary of the coal measures since this is almost entirely obscured, and (2) determining the variations in thickness of the sediments overlying the granite, the gravity effect of the sediments being proportional to their thickness. This is equivalent to determining the topography of the basement.

Although the gravity method has been used elsewhere (e.g. Leigh Creek, S.A. and Blair Athol, Q.) for locating coal seams as such, it was found that the method could not be successfully used for this purpose in the Collie area with the instrument then available. The aim therefore, has been to make a general coverage of the whole field, rather than a detailed treatment of any one section.

The relative gravity values were determined at 767 stations distributed over an area of more than 100 square miles. Owing to the necessity for transporting the gravity equipment by motor truck the traverse lines were located along roads wherever possible. Over a large part of the basin where there are no roads, the selection of traverse lines was considerably restricted by the inaccessible nature of the country due to swamps, creeks, dense timber and laterite ridges. These remarks apply particularly to the southern parts of the coal basin but it was found possible to make readings on several traverses well beyond the previously accepted southern boundary.

In addition to the gravity meter observations, it was necessary to make theodolite surveys of the traverses so that the positions of the stations could be plotted accurately, and to carry out levelling to determine the station elevations within $\pm$ 1 foot.

## IV. RESULTS AND INTERPRETATION.

### (a) General.

For each station the reading of the gravity meter has been corrected for barometric pressure at the time of reading and for the characteristic drift of the instrument. This gives the "observed" gravity value, which is in turn corrected for the latitude and elevation of the station to obtain finally the "reduced" gravity value. The reduced gravity values have been plotted and contours representing lines of equal reduced gravity have been drawn. These are shown on the accompanying plan (Plate 1.). On the plan the contour interval is 1 milligal. This plan will be referred to in the following discussion.

Although the full analysis of the results is not yet complete, it is possible to deduce, from the gravity data shown on the plan, the extent of the coal basin and the main features of the topography of the basement.

Brief mention should be made of a regional anomaly which was found to be superimposed on the local anomaly due to the coal basin. The regional gravity gradient is mainly directed from north-west to south-east and produces a change of about 20 milligals over the full extent of the coal basin, but it is not uniform enough to allow exact corrections to be applied to eliminate it. With due consideration of the regional effect, the interpretation of the gravity contour plan is based on the following two points:-

(1) The gravity "lows", which are clearly shown by the closed contours, indicate the deep parts of the basin.

(2) The boundary of the coal measures is indicated by a steep rise of the gravity values where the traverses pass from the sediments to the granite.

(b) Boundary of the Coal Measures.

The second consideration just referred to has been used in drawing the boundary which is shown on the plan. In a few places where the gravity data are not conclusive it has been possible to complete the boundary by reason of the occurrence of small granite outcrops, which have been accurately located by reference to the surveyed gravity traverses. Where shown by a dotted line the boundary is only approximate. In the area to the south-south-east of Muja siding, the absence of any steep gravity gradient, together with the uncertainty as to the regional effect, makes itimposssible to fix the boundary from the gravity values as precisely as in other places and furthermore, surface indications are not conclusive.

By reference to earlier reports such as "Report of the Royal Commission on the Collie Coalfield, 1940", and "Report of the State Mining Engineer, 1944", it will be seen that the previously accepted boundary is essentially correct on the south-western and northern sides of the basin, but to the north-east of Shotts townsite it should be moved outwards; i.e. to the north-east., by about $\frac{3}{4}$ mile; in the southern and south-eastern parts it requires complete revision. From the south-eastern end of the field a large tongue of granite, indicated by a gravity "high" and confirmed by a few small outcrops, extends almost to the centre of the basin. The existence of the granite inlier shown on maps accompanying previous reports immediately south of Shotts is confirmed but it appears, from the geophysical results, to extend further to the south-east and also to the north-west and closer to the Stockton Colliery, than was previously recognised. There is no evidence of the small granite inlier shown on earlier plans at the southern boundary of the Mining Leases 139 and 140 and this is probably an incorrect plotting of an outcrop of Pre-Cambrian basic rock which occurs approximately $1\frac{1}{2}$ miles east-north-east on Mining Lease 146.

(c) Configuration of the Basin.

The main features of the basin are shown by the gravity contour plan, since the pattern of the basement contours will be very similar to that of the gravity contours.

Estimates of the thickness of the sediments have been made, using a provisional density difference of 0.5 between the sediments and granite, which is assumed to form the basement. The figures quoted below must be regarded as tentative. It will be possible to calculate more precise figures for the thickness of the sediments in different parts of the field when a few test holes have been drilled and more exact determinations of the specific gravities of the rocks have been made. The whole basin is divided into two parts by a more or less continuous ridge in the basement extending from the south-eastern end through the granite "high" near Shotts to the southerly directed projection of granite in the vicinity of Ewington. On the west of this ridge there is a large trough with its centre approximately one mile east of the Cardiff Colliery. This is the deepest part of the basin and the sedimentary rocks are probably about 4,000 feet thick. To the north of this and south-west of the Collie townsite there is a shallower depression where the thickness of the sediments is about 2,600 feet. On the eastern side of the ridge there appear to be two smaller basins one north-east of Shotts and the other south-west of Muja, each with an estimated thickness of sediments of about 3,000 feet.

## V. DRILLING RECOMMENDATIONS.

Only a few drill holes in the Collie area have reached the basement and these are all situated near the boundary of the coal measures. Consequently there is a lack of data available for making a detailed quantitative interpretation of the gravity results and this is particularly important in dealing with the deeper parts of the basin where the density contrast between the basement and sediments, as required in the calculations, cannot be satisfactorily deduced from near-surface density measurements. To provide adequate control data for the geophysical work and, at the same time, greatly enhance its value, it is considered that seven bore holes should be put down to the basement in the vicinity of the points marked A - G on the accompanying plan. The positions of the boreholes A, B, C, and D have been selected in the deepest parts of the basin for the reason mentioned above, while the bores at E, F and G are desirable to eliminate the ambiguity in interpretation which arises from the regional anomaly. The bore at G would serve to fix that section of the boundary now considered doubtful. In addition to determining the depth and the complete geological sequence down to the basement, these boreholes would also give useful information concerning the distribution, quality and thickness of the coal seams.

## VI. CONCLUSION.

It has been pointed out earlier in the report that there was previously considerable doubt as to the extent of the Collie Coal Basin and that particularly in the south-eastern portion the accepted boundary was mainly conjectural. By carrying out the gravity survey in as comprehensive a manner as the conditions permitted it has been possible to establish, with considerable success, the full extent of the Coal Basin. Furthermore, the gravity results can be interpreted to show the general structure of the Coal Basin and the depths of sediments overlying the basement. From the results of the geophysical survey it is therefore possible to define those areas, where there is sufficient thickness of sediments to enable drilling to be carried out with a reasonable expectation of proving additional reserves of coal.

(N. G. CHAMBERLAIN,)
Geophysicist.

Melbourne,
7th August, 1947.

PLATE 1

ALLANSON TOWNSITE

WESTRALIA COLLIERY

CO-OPERATIVE COLLIERY

EWINGTON

COLLIE TOWNSITE

WALLSEND COLLIERY

ML247 (A)

PROPRIETARY COLLIERY

GRIFFIN COLLIERY

SOUTH COLLIEBURN TOWNSITE

COLLIEBURN COLLIERY

BRANCH

CARDIFF TOWNSITE

CARDIFF COLLIERY

COLLIE RIVER

EAST BRANCH COLLIE RIVER

ML279 (E)

STOCKTON COLLIERY

SHOTTS TOWNSITE

PREMIER COLLIERY

ML293 (C)

ML262

ML135 (F)

ML295

MUJA

ML299

ML300

LOC.1736 (G)

ML139

ML140

ML146

ML186 (B)

LOC.4169

LOC.4165

MAGNETIC TRUE

3°45'

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

# GEOPHYSICAL SURVEY OF COLLIE COALFIELD, W.A.

PLAN SHOWING

## RESULTS OF GRAVIMETRIC SURVEY

THE CONTOURS REPRESENT RELATIVE REDUCED GRAVITY VALUES IN MILLIGALS

BOUNDARY OF COAL MEASURES DEDUCED FROM GRAVIMETRIC WORK } SHOWN THUS — PROBABLE, ····· APPROXIMATE

OUTCROPS OF BEDROCK " "

SITES RECOMMENDED FOR TEST BORES " " (A)

N. J. Chamberlain
GEOPHYSICIST
25-7-47.

40 20 0 40 80 120 160 200
SCALE IN CHAINS

G11