Report on Gravity and Magnetic Test Surveys near Wollongong N.S.W.

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REPORT ON GRAVITY AND MAGNETIC TEST SURVEYS NEAR WOLLONGONG, N. S. W.

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GEOPHYSICAL SERIES 1948/10.

Plans No 637, 1 2 + 3

I INTRODUCTION

At the request of the Broken Hill Proprietary a geophysical test survey, employing gravity and magnetic methods, was carried out near Wollongong, N.S.W. by geophysicists of the Bureau of Mineral Resources, Geology and Geophysics.

The area over which these tests were made is part of the Southern Coalfield of N.S.W. and plans are being made to develop a colliery in it. The center of the area lies approximately five miles west of Wollongong near the Cordeaux No. 1 Reservoir and adjacent to an area of outcropping basalt mapped by L. F. Harper as the "Cordeaux flow". The subsurface geology is known in part from five drill holes, namely, Nebo No. 2, 5 and 6 and Wongawilli No. 7 and 8. Basalt sills of considerable thickness were encountered in Nebo No. 6 and Wongawilli No. 8 and it is reasonable to assume that the "Cordeaux flow" is the exposed part of these or similar sills. The sills, however, are absent in Nebo No. 4 and Wongawilli No. 7 and only a narrow sill is present, but at a much deeper horizon, in Nebo No. 5.

The proximity of sills to the coal seams has resulted, in parts of the Southern Coalfield, in the cindering of the coal, and for this reason it becomes a matter of considerable importance in planning a colliery to know the area occupied by the sills.

There are reasons for believing that the sills may end abruptly on steep faults or joints. If the sills which were intersected in Wongawilli No. 8 terminate abruptly between this drill hole and Nebo No. 4 and 6 and Wongawilli No. 7 respectively there appeared to be a reasonable chance that either the gravity or magnetic methods, or both, would indicate where this termination occurred.

II TECHNICAL MATTERS.

The tests were carried out during May 1948 by Messrs. J. C. Dooley and E. R. Smith, geophysicists of the Bureau assisted by surveyors and helpers provided by the Company.

Gravity and magnetic observations were made along four traverse lines, lettered A, B, C, and D, radiating from Wongawilli No. 8 drill hole towards Nebo No. 6, Nebo No. 5, Wongawilli No. 7 and Nebo No. 4 respectively. These traverse lines are shown on Plate G37-1.

The topography of the area covered by these traverses is rough and steep and slopes of 1 in 3 are not uncommon. It is covered for the most part by rain forest with thick undergrowth which made working difficult. Several deeply erroded valleys cross the area which lies at an average elevation of approximately 1200 feet above sea level. To the immediate east of Nebo No. 5 is a ridge with elevations of over 1700 feet while hills of similar elevation lie to the south and west. As a consequence, terrain and topographic corrections for the gravity results assumed large proportions and individual corrections are subject to relatively large errors. The surveying was carried out by

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the Company's surveyors who made, for the purposes of the corrections mentioned above, an accurate contour survey of the area lying approximately 500 feet on either side of the traverse lines. The topographical corrections for more distant parts were calculated from a Water Board survey plan with contours at 500 feet intervals.

Some of the traverses were surveyed alongside wire fences in order to take advantage of the clearings, and magnetic readings were offset 50 feet to avoid the effect of the iron wires. With the exception of traverse A, which extended from Wongawilli No. 8 to Nebo No 6, none of the traverses bridged the interval between Wongawilli No. 8 the other drill holes where the geological section was known. They were limited in length partly because it was believed that the sills would terminate relatively close to Wongawilli No. 8 drill hole and partly because of the difficulty of extending them further.

In Wongawilli No. 8 drill hole two thick basalt sills were intersected; the upper one at 70 feet depth was approximately 100 feet thick and the lower one intersected at 235 feet depth was approximately 65 feet thick. The basalt in the upper sill differs appreciably in appearance from that of the lower sill but their relative densities are about the same and average 3.05.

In Nebo No. 6 these two sills, judging from the appearance of the two distinct types of basalt encountered, have joined into a single sill 260 feet thick at a depth of 140 feet.

The coal measures which these sills have invaded comprise interbedded sandstone, shale, grit and conglomerate, and contain, near the base of the drilled section, three coal seams. An analysis of the gravity results for the purpose of determining an elevation correction factor, which is a function of the density, gives an average relative density of 2.40 for the coal measures. There is therefore a pronounced density contrast (3.05 - 2.40 = 0.65) between the coal measures and the basalt, and it is a simple matter to calculate the gravity anomaly which could be expected when a basalt sill of known thickness terminates abruptly. The sudden termination of the two sills (total thickness 165 feet) in Wongawilli No. 8, for example, would cause a gravity anomaly of 1.3 milligals which could be easily detected with modern types of gravimeters, providing there are no disturbing influences which would tend to obscure the anomaly. The Western Meter used in the tests can measure changes in "g" of the order of ± 0.03 milligals, so that theoretically it should be possible under ideal conditions to determine by gravity method where a basalt sill a few feet thick terminates. However, it was evident from the results over traverse A, between Wongawilli No. 8 and Nebo No. 6, that the change in gravity between these drill holes was much less than would have been recorded had that change been due entirely to the change in thickness of the known sills. It is possible that other sills exist beneath the coal seams and that the difference between observed and calculated gravity change referred to above, may be due to unknown sills varying in thickness. However, an alternative explanation, which is thought more probable, is that there is a gravity gradient due perhaps to basement topography superimposed on the effects due to the sills and this regional effect obscures in part, the effect due to the change in sill thickness.

From the magnetic point of view the problem seemed reasonably simple too. Basalt has generally a relatively high magnetite content which would render it more magnetic than the enclosing coal measures. Tests made by holding core samples near the magnetometer showed that it had a relatively high magnetic susceptibility. The sudden termination of a thick basalt sill could therefore be expected to produce some distortion in the Earth's magnetic field. The Earth's field would tend to crowd into the more magnetic material but with a relatively steeply dipping magnetic field, such as is normal for these latitudes, the effect would only be apparent over the edges of the sill and normal vertical intensities would be measured over the central portion. The attitude of the edge of the sill relative to the Earth's field would affect the size of the anomaly measured, the biggest effect occurring when the edge is normal to the field. The relation between induced and permanent magnetisation is also a important factor in determining the magnetic anomaly due to an edge. The problem of interpreting magnetic results for relatively simple geological conditions such as these is therefore complicated by a number of unknown factors and especially by the fact that the effects are limited to "edge effects".

III <u>RESULTS OF THE TEST</u>.

The results of the tests are shown on Plates G37-2 and G37-3 in the form of gravity and magnetic profiles for the traverses, and geological sections calculated from the gravity results.

The magnetic profiles show portions where the magnetic field has a uniform value of approximately 200 gammas and portions where the magnetic field is disturbed. From what has been said in the preceding section it is evident that the value of the magnetic field in the portions where the field is uniform holds no clue to the thickness of magnetic material underlying the traverse. The disturbed portions could, however, correspond to places where the magnetic field has been disturbed by abrupt changes in thickness of the sills or where there is some other abnormal condition of magnetisation within the sills. It seems likely that the sills alone are responsible for magnetic anomalies although iron stained sandstone and black shale containing nodules of iron carbonate were found to be very weakly magnetic and some of the magnetic disturbance could have been caused by outcrops of such beds. Cores of basalt were not only strongly magnetic but showed definite polarity indicating a high degree of permanent magnetisation.

One disturbed section on traverse B coincides with an outcrop of basalt. An attempt at interpretating other disturbed sections in terms of basalt sills terminating abruptly gives a picture which is at variance, for the most part, with that obtained by the gravity method. In addition there are sections of uniform magnetic field coinciding with places where the gravity results suggest the sudden termination of a sill (for example near station 9 on traverse C) and where conditions would seem to be most favourable for the occurrence of an appreciable magnetic anomaly.

Since in this problem the gravity anomalies are subject to fewer variable factors influencing their size and shape they are to be preferred to the magnetic anomalies for purposes of interpretation.

The geological interpretations shown on the section lines on Plates G37-2 and G37-3 are somewhat tentative in that they must depend on the following assumptions -

(1) That the sills terminate abruptly on vertical or near vertical faults or joints.

(2) That the sills conform to the bedding planes.

(3) That any unknown sills which lie beneath the coal are either thin or uniform in thickness over the area tested.

(4) That a gravity gradient of a deep seated origin accounts for the difference between calculated and observed gravity change between drill holes Wongawilli No. 8 and Nebo No. 6.

(5) That a similar gravity gradient can be assumed for the traverse joining Wongawilli No. 8 and Nebo No. 5.

The observed gravity values, regional gravity gradients assumed under (4) and (5) above, and gravity values corrected for regional gradient are shown as profiles on the Plates and the corrected profiles have been used in the interpretation.

It will be noted that on traverse A, the corrected value for Nebo No. 6 is 0.7 milligals higher than the mean value near Wongawilli No. 8, corresponding to the increase of 95 feet in combined thickness of the two sills.

Bearing in mind the limitations set by the assumptions made in the interpretation it will be seen that the corrected profile through traverses A and C correspond to major changes in sill thickness at A 5½, C 9 and C 18 and minor changes in thickness at A 13½ and A 23½.

Superimposed on the corrected observed profile are gravity values calculated for the geological section shown and the fit is reasonably good.

For the east-west section along traverses B and D a regional gradient was assumed and observed gravity values corrected accordingly. There is no fundamentally sound reason for assuming that such a regional gradient does in fact exist beyond the somewhat doubtful assumptions that the slope of the observed profile between stations B 14 and B 20 reflects this regional gradient and that from Wongawilli No. 8 eastward the thickness of the sills and consequently the corrected value of "g" will decrease by steps.

A calculated geological section is shown with the corrected profile. To the east of the origin it shows a minor decrease in the thickness of the upper sill near B 10 and the two sills terminating near B 28. The assumption of a different regional gradient however could affect the interpretation insofar as the changes in thickness of the sills are concerned, but it seems reasonably certain that a substantial change of thickness occurs near B 10 and that a bigger change in thickness occurs not far to the east of B 28. The observed (and corrected) gravity values are decreasing rapidly over the last few points on the traverse and this trend may persist still further east. The gravity values calculated for the geological section fit the corrected profile reasonably well but because of the unsubstantial basis on which this interpretation is obtained it can be accepted only with considerable reserve.

At the western end of the profile - over traverse D - a minor variation in sill thickness is indicated between D 9 to D 14.

In calculating the gravity effects from the geological sections it has been assumed in each case that the traverses are normal to the edges of the sills. A substantial departure from this condition could lead to gross errors in estimating the depth at which the change in thickness occurs but should not effect greatly the estimated position or the magnitude of the change.

IV CONCLUSIONS.

The geophysical test, although limited in their application, have shown that magnetic and gravity methods do not provide any simple or direct way of mapping basalt sills in the problem under consideration. In a general way, the gravity method has indicated places where sudden changes in thickness of the basalt sills are believed to occur. These changes may coincide with faults or joints, and attention is drawn to the suggested termination near S 28 which is on the south westerly prolongation of a known fault.

It is possible, however, that the geological picture has been over simplified. The complexity of the magnetic and to a lesser degree of the gravity results may in fact be truly indicative of the complexity of the geological conditions. The geological sections revealed by subsequent drill holes in this area may provide clues to the interpretation which at present are not evident. However, on present showings further work by geophysical methods on this particular problem cannot be recommended.

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