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GRAVITY TRAVERSE NEAR BULLSBROOK, WESTERN AUSTRALIA

by

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GRAVITY TRAVERSE NEAR BULLSBROOK, WESTERN AUSTRALIA.

At the request of the Government Geologist of Western Australia some gravity observations were made near Bullsbrook, a small township on the Perth-Geraldton road, 27 miles from Perth. It was thought that the gravity observations would help resolve a problem connected with the water supply of the township on which the advice of the Geological Survey of Western Australia had been sought.

Local authorities had proposed deep boring within the precincts of Bullsbrook for domestic water supply, their proposal no doubt being inspired by the water service to the R.A.A.F. aerodrome at Pearce. This establishment lies on the northern outskirts of Bullsbrook and is served by a deep bore near the Bullsbrook railway siding about 2 miles west of the township from which large quantities of potable water are pumped.

The Problem.

Although Bullsbrook lies on sediments mostly sand and clay, it is by no means certain that a deep bore could be drilled without encountering basement rocks at a comparatively shallow depth. The main scarp of the Darling Range which marks the western edge of the Pre-Cambrian shield of Western Australia lies only a short distance to the east of the township. The Pre-Cambrian basement rocks are mainly granite and metamorphics and generally do not yield potable water. On the other hand, the sediments generally contain porous sand beds which may be suitable aquifers. It is evident then that a prior knowledge of the thickness of the sediments underlying the selected bore site would be of considerable value.

It has long been suspected that the Darling scarp marks the trace of a major fault. If this is so and the fault lies sufficiently far to the east of Bullsbrook, a deep bore can be sited anywhere in the township without fear of encountering basement rocks at shallow depth, although whether or not such a bore would encounter suitable aquifers would remain unresolved. On the other hand, if there is no fault and the sediments have been deposited on a gently shelving basement, it is most likely that the nearby scarp presages shallow basement beneath Bullsbrook.

Because the gravity method has proved successful elsewhere in determining the thickness of sediments overlying dense basement rocks, it was thought that some estimate of the thickness of sediments underlying Bullsbrook could be made by using the method. There is an adequate density contrast between the Pre-Cambrian basement rocks (which average about 2.7) and the sediments which, as far as is known, average about 2.15.

Operations.

The gravity observations were made with a Norgaard gravimeter and were tied to a pendulum station at Perth. Station locations were spotted from the Australian Army Survey 1-mile maps of Yanchep and Toodjay. Elevations were read with barometers except for Station (b) at Bullsbrook railway siding, where an accurate railway bench mark served as a suitable reference level. Levels had a probable accuracy of $\pm$ 10 feet which was sufficiently accurate for the purpose of the survey.

One afternoon, July 7th, 1951, was required for the observations which were made at eleven stations. The writer was assisted by Mr. J. R. H. van Son. Corrections were made for elevation (correction factor 0.07 milligals. per foot) and latitude and the results are expressed as Bouguer anomalies relative to theoretical values for the International Ellipsoid. Isostatic corrections were not made.

Results and Interpretation.

Observation points with corresponding Bouguer anomalies are shown on the accompanying plan. Stations (f) and (g) have approximately the same anomaly and serve to fix a direction for the gravity contour lines. These are roughly parallel to the Darling scarp as can be seen by comparing the gravity contours with the ground contour lines shown. Bouguer anomalies increased from west to east and range from -93 to -12 milligals. Isostatic anomalies would have been more negative. Such large negative anomalies are commonly associated with large rock masses with density less than normal. Anomalies are shown in section on the accompanying plate on which the observed values are compared with theoretical values calculated for a geological section which features a major fault. It will be noted that the fit between observed and calculated values is very close, and the gravity observations are therefore consistent with the existence of a major fault which outcrops at the foot of the Darling scarp. Although such an interpretation is not unique, i.e., there are alternative explanations for the results, it is believed that in this problem the interpretation is a reasonable one and probably represents the geological facts. The enormous gravity gradient that is revealed can only be explained by the presence of a major change in density either extending to, or close to, the surface. No reasonable distribution of masses, which includes a shallow basement under Bullsbrook, can be postulated to fit the gravity data.

According to the calculations, the most probable position for the fault outcrop is near Station (h) at the foot of the Darling scarp. This position is marked by a line on the accompanying plate which has been extended north and south (shown broken) parallel to the scarp. The line passes about ½ mile to the east of Bullsbrook but the uncertainty of its position is of the order of ± ½ mile.

The magnitude of the fault calls for some comment. The gravity results are consistent with a steeply dipping (80°) normal fault with an accumulation of approximately 22,000' of sediments on the westward or ocean side providing -

(a) The anomaly is due entirely to such sediments, and

(b) The density contrast is 0.55.

Some part of the anomaly may, in fact, be due to displacement of dense material at the base of the earth's rigid crust. The effect of such deep causes, however, would necessarily be diffusive and gravity gradients due to it relatively small. It seems probable that at least only a minor part of the anomaly could be due to such a cause. The actual density contrast cannot be determined experimentally, but it seems likely that it would be less than 0.55. The calculated maximum thickness of the sediments is inverse proportionately to the density contrast and any reduction in the contrast would lead to an increase in the thickness of the sediments. The average density of the sediments may be as high as 2.4 and consequently their total thickness may be as much as 40,000'.

Conclusions.

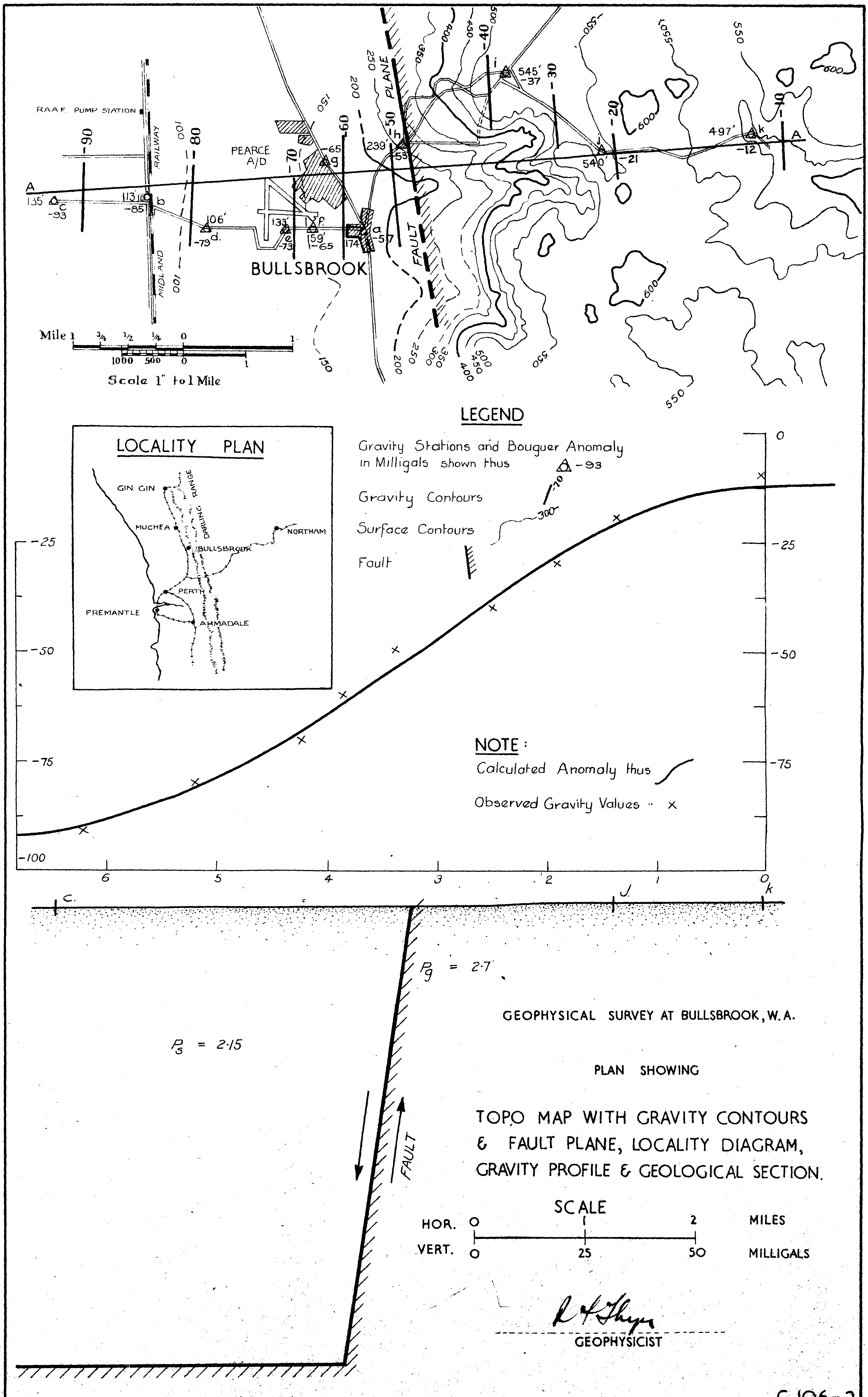
The gravity results indicate that the Darling scarp near Bullsbrook coincides with the steeply dipping (80°) normal fault. The fault lies about $\frac{1}{2} \pm \frac{1}{4}$ mile to the east of the main road at Bullsbrook. A tremendous thickness of sediments has been deposited on the westward or ocean side of the fault, and their total thickness is believed to exceed 20,000' and may possibly be as much as 40,000'. It is considered that deep boring could be undertaken anywhere to the west of the main road through Bullsbrook without fear of encountering basement rocks at a depth less than 5,000' (an assumed lower limit to such boring), and probably much deeper. Whether or not suitable aquifers would be encountered by such deep boring cannot be determined from the gravity results.

(R. F. THYER)

Melbourne.
September, 1951.

Distribution :

Original - File 45W/1B.
1 - Government Geologist, W.A.
2 - " " "
3 - Professor R. T. Prider, Perth University.
4 - Chief Geologist, Canberra.
5 - Geophysical Library.
6 - " "


RAAF PUMP STATION
PEARCE A/D
BULLSBROOK
MIDLAND RAILWAY
FAULT PLANE
FAULT
Mile 1 ¾ ½ ¼ 0 1
1000 500 0 1
Scale 1" to 1 Mile
LOCALITY PLAN
GIN GIN
MUCHEA
DARLING RANGE
BULLSBROOK
NORTHAM
PERTH
FREMANTLE
ARMADALE
LEGEND
Gravity Stations and Bouguer Anomaly in Milligals shown thus
Gravity Contours
Surface Contours
Fault
NOTE:
Calculated Anomaly thus
Observed Gravity Values "
$\rho_g = 2{\cdot}7$
$\rho_s = 2{\cdot}15$
FAULT
GEOPHYSICAL SURVEY AT BULLSBROOK, W.A.
PLAN SHOWING
TOPO MAP WITH GRAVITY CONTOURS & FAULT PLANE, LOCALITY DIAGRAM, GRAVITY PROFILE & GEOLOGICAL SECTION.
SCALE
HOR. 0 1 2 MILES
VERT. 0 25 50 MILLIGALS
GEOPHYSICIST
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