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REGIONAL GRAVITY TRAVERSES ACROSS THE EUCLA BASIN, 1954-55

by

S. Gunson and J. van der Linden

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ABSTRACT

Results are given of a regional gravity survey carried out by the Bureau of Mineral Resources across the Eucla Basin and continued westwards as far as East Northam, Western Australia. Readings were taken at intervals of about 5 miles along 1,975 miles of traverse. Railway lines were followed where possible, level data being available from Commonwealth and State Railways for 1,136 miles of traverse. The remainder was levelled using microbarometers.

Bouguer anomalies are plotted as profiles along each traverse, using a density value of 2.67. No detailed interpretation is attempted, as this would involve too much speculation in view of the paucity of geological data. Recommendations are made for additional gravity traverses to join up the two main east-west traverses, and to investigate a steep gravity gradient west of the Eucla Basin.

1. INTRODUCTION

This record presents the results of a regional gravity survey carried out by the Bureau of Mineral Resources across the Eucla Basin in August, 1954, and January to March, 1955. It also includes results obtained along a traverse between East Northam and Kalgoorlie, which, although not in the Eucla Basin, was done during the same survey.

The position of the traverses is shown on Plate 1.

2. GEOLOGY

Because of the size of the area and the fact that it has never been thoroughly surveyed geologically, the following description is of necessity very general.

The traverses cover two major geological regions, namely the Pre-Cambrian Shield of Western Australia and the Eucla sedimentary basin which overlies the shield to the north of the Great Australian Bight.

The Pre-Cambrian Shield consists of granite, granite gneiss and highly metamorphosed sedimentary and igneous rocks of Archaean Age.

Prider (1952) lists the Archaeozoic succession in Western Australia as:

4. Granite (magmatic)

3. Gneisses and magmatites (granitization)

2. Archaean sediments (whitestones)

1. Archaean basaltic lavas (greenstones)

In the eastern part there are many areas of greenstones. These rocks, which are important to the mining industry because the major gold deposits occur in them, are essentially metamorphosed igneous rocks with some meta-sediments. Generally, their composition is basic to ultra basic and their density (2.9 to 3.0) is higher than that of the surrounding acid rocks, (2.6 to 2.7). Whitestones, which are metamorphosed sediments, are another rock type found in the area under discussion. The density of the whitestones appears to correspond roughly to that of granite; samples from the Mt. Ragged Range had a density of 2.69 (Maitland, 1924).

The Eucla Basin consists of Tertiary and Cretaceous sedimentary rocks lying on a Pre-Cambrian basement. The western and eastern margins of the basin are shown on Plate 1. It is not a deep basin; bores on the railway line between Loongana and Forrest reached basement at depths ranging from 1,000 to 1,300 feet. The results of an aeromagnetic survey made by the Bureau (Goodeve and Quilty, 1957) indicate that the depth to Pre-Cambrian basement does not exceed 2,000 feet in that portion of the Eucla Basin covered by the gravity traverses. On the railway line, the western edge of the basin appears to be approximately 30 miles west of Rawlinna and the eastern edge near Ooldea. The eastern edge of the basin is covered by a sand plain in which there are isolated outcrops of granite.

3. OPERATIONS

A. Description of Traverses.

The total length of the traverses is 1,975 miles. Level data for 1,136 miles of this total were obtained from Commonwealth and State Railway Surveys, while the remainder, mostly along the Eyre Highway, was levelled using Askania microbarometers.

The average station spacing is five miles.

The following description of the traverses includes some remarks on general working conditions which may be helpful in future surveys:

(i) Ooldea, S.A. to Kalgoorlie, W.A. This traverse runs along the Trans Australian Railway and was surveyed by J. van der Linden and one field assistant in August, 1954. Stations were located at railway mile posts for which railway levels were available. The traverse connects pendulum stations established by the Bureau at Forrest and Kalgoorlie and is 624 miles long.

A Land Rover and trailer provided the means of transport, and supplies of food, water, and petrol were obtained from the Commonwealth Railways. The traverse was completed in four weeks.

(ii) East Northam, W.A. to Kalgoorlie, W.A. (Traverse W).

This traverse starts at station 214 of the Perth Basin gravity survey (Thyer and Everingham, 1956) and ends at Kalgoorlie on the Eastern Goldfields Railway. All the stations are at rail level, at sidings where possible, but otherwise at level crossings or railway mile posts. The traverse is connected to Bureau pendulum stations at Merredin and Kalgoorlie.

The length of the traverse is 310 miles and it was completed in two weeks.

(iii) Coolgardie, W.A. to Norseman, W.A. (Traverse X).

Traverse X runs south from Coolgardie (W57) on traverse W to Norseman (X21). For the first fifty miles the railway line is inaccessible, and the gravity stations had to be located on the main road. No levels were available along the road, and the gravity stations were levelled using microbarometers. After the first fifty miles railway levels were used in the same way as on Traverse W.

The traverse is 105 miles long and was completed in one week.

(iv) Norseman, W.A. to Ceduna, S.A. (Traverse Y).

This traverse runs east from Norseman along the Eyre Highway to Ceduna, via Balladonia, Madura, Eucla, and Nullarbor. The only levels available were at Norseman, Eucla and Ceduna, and the entire traverse was therefore levelled with microbarometers using the limited control provided by these three stations.

From Norseman to the border of Western Australia and South Australia, gravity readings were taken at every fifth mile post, except where some more important or permanent feature existed. From the border to Ceduna there are no mile posts and most of the country is featureless. Because of this most of the stations were set in by speedometer. Wherever identifiable points were found they were occupied and there are sufficient of these to enable any future work to be tied to the main traverse.

The traverse is 760 miles long and was completed in six weeks.

(v) Mundrabilla, W.A. to Forrest, W.A. (Traverse Z).

Mundrabilla is a homestead sixty miles west of Eucla. Traverse Z follows the track from Mundrabilla to Forrest on the Trans Australian Railway some 75 miles to the north.

With the exception of the first eight miles from Mundrabilla the traverse lies on the Nullarbor Plain. There are no landmarks whatever and all the stations were set in by speedometer.

B. Gravity Measurements.

All the gravity measurements were made with a Wordon portable gravity meter, No. 140. The drift of the meter was measured by making a second reading at each station within two hours of the first reading. At times when the drift was small, usually in the middle of the day, alternate stations only were read twice.

C. Barometric Levelling.

Barometric levelling was done using Askania microbarometers. Three barometers (Nos. 5112362, 5112387 and 5112473) were carried but only two were in use at any one time. The procedure for levelling was as follows:-

One barometer was used as a base instrument and the other as a mobile one. Both barometers were read simultaneously on one station, say Y10. The mobile barometer was then read at stations Y11 and Y12 at the same times as the base barometer was read at station Y10 (using synchronized watches and pre-arranged times). The mobile barometer was then brought back to Y10 and read simultaneously with the base instrument after which the readings on Y11 and Y12 were repeated with the mobile barometer. After this second reading on Y12 the mobile barometer was held there and the base barometer brought up to it for another simultaneous reading. Stations Y12, Y13, Y14 were then read in the same way. As the station separation was about five miles the barometers were never more than about ten miles apart. A similar method of barometric

surveying has been described by Stripling, Broding and Wilhelm (1949). It differs from the method used in this survey in that radio-telephone communication between the base and mobile barometers was used to establish the reading time for each barometer. An advantage of this method is that the two operators can, by consultation, choose a reading time when the barometers indicate the same pressure trends.

The results of the levelling are discussed in the next section.

4. RESULTS

A. Gravity.

The observed gravity values have been reduced to give Bouguer anomalies at sea level and are plotted on Plate 1. The Bouguer correction has been calculated for densities of 2.67 and 2.2. The first value is the internationally accepted standard figure for regional work; the additional reduction for a density of 2.2 was done because the value was considered more suitable for the Eucla Basin. The values on Plate 1 are those obtained using the density of 2.67, and the profiles on the same plate are drawn for this value. There is little variation in relief along the traverses, and the profile for a density of 2.2 is almost identical with the one plotted, though displaced upwards about three milligals.

No terrain correction was applied because of the flat nature of the country and because insufficient survey information is available.

The closure errors to the pendulum stations were as follows:-

1.	Forrest to Kalgoorlie	- 1.20 milligals
2.	Merredin to Kalgoorlie	- 1.25 "
3.	Kalgoorlie to Eucla	+ 1.16 "
4.	Forrest to Eucla	- 1.42 "
5.	Eucla to Ceduna	- 0.18 "

These errors are considered reasonable, taking into account the length of the traverses and the probable error of the pendulum stations (± 0.6 milligals). The errors have been distributed evenly along the traverses. They could have been reduced by adjustment of the pendulum values, but this would have been unsound with the data available.

No detailed interpretation of gravity data in terms of geological sections will be offered here as this would involve too much speculation. Generally, those parts of the traverses which are on the West Australian Shield show the variations in density of the Archaean rocks. This is well marked in the Kalgoorlie area (see Plate 1), where local gravity "highs" are measured over the greenstones and "lows" over the granite and whitestones. This is, of course, compatible with the densities of these rocks. Correlation of this kind is not as obvious on the rest of the traverses but it is important to remember that a large part of this area, at present mapped as granite, may contain whitestone and greenstone rocks whose presence is obscured by a cover of soil and laterite.

An outstanding change in the level of the Bouguer anomalies on the southern traverse (Y) commences 55 miles east of Norseman. The anomalies change from -90 milligals to +30 milligals in a distance of 35 miles. The centre of this change is located at the crest of the Fraser Range. The Fraser Range rises about 500 feet above the surrounding plateau, its highest point being approximately 2,000 feet above sea level. It is described by Wilson (1952) as "the largest known basic charnockite mass in Australia". Wilson further says that this mass has been subjected to a thrust from the south-south-east. In a later paper (Wilson, 1954) he shows a fault striking north-easterly and situated just to the west of the Range. Maitland, (1924) has collected samples from the area with density as high as 3.05 and 3.02.

After the peak value of +30 milligals the anomalies again become negative to the east of Fraser Range but the gradient is lower than that on the western side of the range.

A similar, though smaller, change in Bouguer anomaly occurs on the traverse along the trans-continental railway. The centre of this change is 140 miles east of Kalgoorlie and lies almost exactly on a line extended from the Fraser Range in a north-east direction. The lower gravity values found to the east of these high values on both traverses similarly are collinear with a line extended from the Mt. Ragged Range (west of Israelite Bay), where whitestone is exposed.

The Bouguer anomalies are clearly related to the Pre-Cambrian structures of the Western Australian Shield. Later in this report it is recommended that more gravity work should be done in this area. Interpretation of these results will be more certain when the extent and trends of the gravity anomalies are better known.

The anomalies on both traverses over the Eucla Basin are considered to be mainly an expression of density variations in the basement rocks.

To conclude this section it should be noted that the average of all the Bouguer anomalies is -40 milligals. This is consistent with the fact that Bouguer anomalies on continental areas are generally strongly negative (Daly, 1940, p.120).

B. Barometric Levelling.

The barometer readings were reduced to feet and corrected for temperature and drift. Satisfactory closures on points of known elevation were obtained despite the length of the lines.

The closure errors were:

1.	Norseman to Eucla	(442 miles)	+ 25'
2.	Eucla to Penong	(277 miles)	+ 31'
3.	Forrest to Eucla	(140 miles)	- 23'

The errors were distributed evenly along the traverses.

5. RECOMMENDATIONS

The work described in this record was done as part of the regional gravity survey of Australia and will be supplemented from time to time by additional work on that programme. Subject to this the following recommendations are made:-

(a) The two traverses across the Eucla Basin should be joined by the following north/south traverses:-

(i) Rawlinna to Balladonia.

(ii) Reid to Eucla.

(iii) Cook to Nullarbor.

(iv) Colona to Ooldea.

(b) The strong gravity trend just west of the Eucla Basin should be investigated further. This could be done by a traverse from Balladonia south to Israelite Bay, west to Esperance, then north along the railway line to close at Norseman.

6. REFERENCES

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PLATE I
GRAVITY TRAVERSES ACROSS THE EUCLA BASIN
LOCATION OF TRAVERSES
AND
BOUGUER ANOMALY PROFILES
(GEOLOGY FROM GEOLOGICAL MAP OF AUSTRALIA AND NEW GUINEA, 1952)
GEOPHYSICIST
Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. G 157-3
APPROX. SCALE IN MILES
32 0 32 64 96
LEGEND
Greenstone Series
Whitestone
Gravity Stations
FILE REFERENCES TO DATA
Ooldea - Kalgoorlie Files No 55-034 and 55-035
East Northam - " " " 55-001 " 55-002
Ceduna - " " " 55-003, 55-004 and 55-005
Milligals
INDIAN OCEAN
PERTH
PRE-CAMBRIAN SHIELD
NULLARBOR PLAIN
GREAT AUSTRALIAN BIGHT
SAND PLAIN
Eastern Goldfields Railway
Trans Australian Railway
Eyre Highway
W.A. S.A. Border
FOWLERS BAY
Coolgardie
Kalgoorlie
Norseman
Balladonia
Eucla
Ceduna
Ooldea
Forrest
Esperance
Albany
Bunbury
Busselton
Israelite Bay
115° 116° 117° 118° 119° 120° 121° 122° 123° 124° 125° 126° 127° 128° 129° 130° 131° 132° 133° 134°
31° 32° 33°