COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1963/136

DALY WATERS - NUTWOOD DOWNS REGIONAL GRAVITY TRAVERSE, NORTHERN TERRITORY 1960

by

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SUMMARY

The results of a regional gravity traverse made in 1960 between Daly Waters and the Department of the Interior Survey Peg 72-19, approximately 20 miles beyond Nutwood Downs Homestead, are discussed.

The gravity data have been interpreted in terms of the known geology, including a limited amount of information from water bores in the area, and some conclusions are drawn concerning the thickness of post-Proterozoic sediments and volcanic rocks in the immediate vicinity of the traverse.

1. INTRODUCTION

In 1959 the Geological Branch of the Bureau of Mineral Resources requested a gravity traverse to be made from Normanton (Qld) to Wyndham (WA) via Newcastle Waters (NT), with an extra loop from O.T. Downs Homestead to Newcastle Waters via Tanumbirini, Nutwood Downs, and Daly Waters.

Owing to delays due to vehicular and instrumental troubles, the gravity party in that year, led by A. Radeski, was able to complete only the Normanton-Newcastle-Daly Waters part of the survey, with the addition of three stations from O.T. Downs Homestead towards Tanumbirini (Neumann and Lonsdale, in preparation).

In 1960 the gravity work was resumed by A. Douglas, and the traverse from Newcastle Waters to Wyndham was completed. The traverse from Daly Waters to O.T. Downs Homestead could not be completed owing to bad road conditions; readings were made only as far as Department of the Interior Survey Peg 72-19, some 20 miles beyond Nutwood Downs Homestead.

This Record describes that part of the 1960 survey between Daly Waters and Survey Peg 72-19 (Plate 1). This work was done on the 22nd and 23rd September 1960. A total of 21 gravity stations was read, of which 19 were new stations. Ties were made at Daly Waters to the Bureau's pendulum station and to Peg 71-17.

A gravity station was also established at Nutwood Downs airstrip during a regional survey using commercial airlines in 1959 (Radeski, 1962).

Details of the operations are given in Appendix 3.

2. GEOLOGY

A geological sketch map of the area surrounding the gravity traverse is shown on Plate 1. This map is based on work by the Bureau's Geological Branch (Dunn, 1962; Paine, 1962).

Rocks of five ages occur in the area of the traverse. The sequence (after Dunn, 1962; Paine, 1962) is summarised in Table 1.

TABLE 1

STRATIGRAPHIC SEQUENCE
DALY WATERS TO NUTWOOD DOWNS AREA (NORTHERN TERRITORY)

AGE	FORMATION	APPROXIMATE THICKNESS (feet)	LITHOLOGY
Cainozoic		to 50	Sand, alluvium, soil, laterite
Lower Cretaceous		170 +	Sandstone, siltstone, and conglomerate
? Middle Cambrian	Tindall Limestone	65	Limestone with chert nodules
Lower Cambrian	Nutwood Downs Volcanics	400	Basalt with inter-bedded sandstone
	Bukalara Sandstone	200 +	Sandstone
Upper Proterozoic		18,000 +	Quartzite, sandstone, siltstone

The Upper Proterozoic rocks were deposited in the central-west portion of the McArthur Basin (Dunn, op. cit.) and were extensively deformed and uplifted before Cambrian times. The Cambrian and later sediments are almost undeformed veneers overlying the folded Upper Proterozoic rocks, having been weakly faulted and folded along lines of weakness (Paine, op. cit.).

From Daly Waters to Peg 72-8 the traverse passes over Cainozoic deposits with small outcrops of Lower Cretaceous sediments. At Peg 72-8 the traverse crosses a scarp onto a larger outcrop area of Lower Cretaceous sediments which is continuous to beyond Peg 72-12, except for a small outcrop of Upper Proterozoic sandstone mid-way between Pegs 72-11 and 72-12. Beyond Peg 72-12 the traverse crosses Lower Cambrian Nutwood Downs Volcanics which persist to Peg 72-17, after which the remainder of the traverse again lies over outcrops of Lower Cretaceous sediments.

A number of water bores have been put down in the area adjoining the traverse (see Appendix 1) and the rather-limited data from these, provide some useful information on the thickness of the post-Proterozoic rocks.

It seems likely that the Proterozoic sandstone that crops out between Pegs 72-11 and 72-12 and was penetrated in Bore No. 2 forms part of a near-surface structure extending along a north-west to south-east-trending line, since the bore-hole data north-east and south-west of this line reveal certain important differences in the post-Proterozoic sequence.

Bores put down south-west of this line pass through post-Cambrian sediments increasing in thickness to the south-west (known maximum thickness of 150 ft in Bore No. 5, with 171+ ft of probable post-Cambrian sediments in Bore NA) before entering the Middle Cambrian Tindall Limestone. This limestone has only been completely penetrated in Bore No. 5 where it was found to be underlain by 7+ ft of sand and gravel. No volcanic rocks were encountered in the bores in this area although they may occur at greater depth.

North-east of this line the bores either encountered very thin Tindall Limestone above the Lower Cambrian volcanics or else penetrated the volcanics immediately beneath thin (50 ft average) post-Cambrian sediments.

3. GRAVITY RESULTS

Bouguer anomalies based on the 1962 observed gravity value of Daly Waters pendulum station (Dooley, 1962) have been calculated for each of the stations using density values of 1.3, 1.9, 2.2, and 2.67 g/cm^3.

The gravity values plotted on Plate 1 are those obtained using a density value of 2.67 g/cm^3. On Plate 2 gravity profiles with anomaly values based on the four densities above are shown together with a topographic profile along the road from Daly Waters to Peg 72-19.

It will be noted on Plate 2 that the Bouguer-anomaly curve calculated using a density value of 1.9 g/cm^3 in the vicinity of Peg 72-8 mirrors the elevation increase over the Lower Cretaceous scarp at this point; this indicates that the density value used is too high, since the use of a higher density increases this effect. The use of a lower value removes this effect (Plate 2) and it would appear that the Lower Cretaceous rocks forming the scarp have a density of approximately 1.3 g/cm^3. This density seems abnormally low, and not much reliance can be placed on it, especially as it depends on a reading at one station only. As it is near the edge of a scarp, terrain effects may account for some of the deficiency or the scarp may be associated with a geological feature causing the anomaly.

Gravity values indicate that there are two sections of the traverse in which high-density rocks crop out or are present at shallow depth. These sections are (a) in the vicinity of Peg 72-1 near Daly Waters and (b) east of Bore No. 2 (midway between Pegs 72-11 and 72-12).

Owing to the lack of gravity information north, west, and south-east of Daly Waters, the extent and nature of the gravity 'high' at Peg 72-1 is difficult to assess. However, the gravity results indicate that high-density rocks, which are tentatively suggested to be Upper Proterozoic sediments, occur at shallow depth beneath the Cainozoic sediments there.

Along the section of the traverse situated east of Bore No. 2 the gravity interpretation is complicated by a major density reversal due to Cambrian volcanics of density 2.98 g/cm^3 (Appendix 2) overlying lighter Proterozoic sediments including siltstone, shale, and sandstone of average density 2.52 g/cm^3. Consequently, along this section of the traverse gravity 'highs' will probably correspond to areas of thick volcanics rather than near-surface Proterozoic rocks. The densities were measured on surface samples, and may be too low because of weathering processes, although the samples appeared to be reasonably fresh.

In order to estimate the thickness of the volcanic rocks along this part of the traverse, a regional-anomaly curve based on the known outcrops of Proterozoic rocks near Bore No. 2 and near Peg 72-16 has been drawn between these points for the Bouguer-anomaly values calculated using a density of 2.67 g/cm^3 (Plate 2). This density value is considered to be fairly representative of the near-surface rocks along this part of the traverse.

This regional anomaly has been removed from the actual anomaly to obtain a residual anomaly (Plate 2) which is considered to be produced by the volcanic rocks.

The residual anomaly so obtained has been investigated by means of the formula :

$$\Delta g = 12.77 \rho h$$

where Δg is the gravity effect due to the volcanic rocks

ρ is the density contrast between the volcanics and the Proterozoic sediments (0.46 g/cm^3)

and h is the thickness of the volcanics in thousands of feet.

By this means it is estimated that the volcanic rocks, which are absent in Bore No. 2, are thin (say not more than about 100 ft thick) between Pegs 72-12 and 72-14. Between Pegs 72-14 and 72-15 the traverse crosses a known fault and at Peg 72-15 the volcanics appear to increase in thickness, indicating that the fault has a downthrow of about 300 ft to the east. South-east of Peg 72-15 the volcanics decrease in thickness very rapidly towards Peg 72-16 and probably are absent a little farther south-east. However, south-east of Peg 72-17 the increasing gravity values indicate that the volcanic rocks are again present at shallow depth beneath the outcropping Cretaceous and Recent sediments and this is confirmed by the drilling results of Bores No. 1 and 10 (Plate 2).

A broad gravity 'low' extending from Peg 72-1 to Bore No. 2 indicates post-Proterozoic sediments overlying the Proterozoic rocks. The thickness of these sediments was also investigated by means of the formula quoted above, with :

Δg the gravity effect due to the post-Proterozoic sediments,

ρ the density contrast between these sediments and the Proterozoic rocks, and

h the thickness of the post-Proterozoic sediments in thousands of feet.

The probable value of the average density of the post-Proterozoic sediments along this part of the traverse was assessed using the bore-hole data. It was found that a value of 2.2 g/cm^3 would be reasonable, corresponding to 150 ft of Cretaceous sediments and 65 ft of Tindall Limestone overlying Lower Cambrian Bukalara Sandstone, which itself has a density of 2.2 g/cm^3. It was assumed that the top 30 ft of the Cretaceous sediments are lateritised and that the Nutwood Downs Volcanics are either not present along this part of the traverse or else are of negligible thickness. Hence the density contrast between the Proterozoic rocks and the later sediments between Peg 72-1 and Bore No. 2 is taken to be 0.3 g/cm^3.

Inserting this value into the formula quoted earlier and assuming that at Peg 72-1 the Proterozoic rocks are very near the surface, it would appear that eastwards from that point the post-Proterozoic sediments thicken to about 1000 to 1500 ft between Pegs 72-4 and 72-10 before thinning to zero at Bore No. 2.

With regard to the identity of these sediments it is suggested that the main part of the sequence is composed of Bukalara Sandstone or similar beds. Any thickening of the Tindall Limestone would result in a lower density-contrast value than assumed and hence the total thickness of post-Proterozoic sediments would be greater than that calculated; a thickening of the Cretaceous sediments would have the opposite effect on the calculated thickness.

4. CONCLUSIONS

Post-Proterozoic rocks of varying thickness overly Proterozoic rocks along the traverse. Near Peg 72-1 the Proterozoic rocks probably approach close to the surface. Between Pegs 72-2 and 72-11 it is suggested from the gravity data that post-Proterozoic sediments are up to about 1500 ft thick. East of Peg 72-11 post-Proterozoic rocks, mainly composed of Lower Cambrian Nutwood Downs Volcanics, crop out and, according to the gravity data, attain a thickness of about 400 ft at Peg 72-15 (Nutwood Downs Homestead). These beds persist beneath thin Cretaceous and Recent sediments south-east of Peg 72-17.

5. REFERENCES

DOOLEY, J.C.	1962	Australian gravity network adjustment 1962 Bur. Min. Resour. Aust. Rec. 1962/141 (unpubl.)
DUNN, P.R.	1962	Explanatory notes, Hodgson Downs 1:250,000 geological sheet. Bur. Min. Resour. Aust. Rec. 1962/90 (unpubl.)
MACKAY, N.J.	1957	Report on water supply at Nutwood Downs Station, Northern Territory. Bur. Min. Resour. Aust. Rec. 1957/61
NEUMANN, F.J.G. and LONSDALE, G.F.	-	Normanton - Daly Waters gravity traverse, Qld and NT 1959. Bur. Min. Resour. Aust. Rec. (in preparation)
PAINE, A.G.L.	1962	Explanatory notes on the Tanumbirini 1:250,000 sheet area, NT Bur. Min. Resour. Aust. Rec. 1962/135 (unpubl.)
RADESKI, A.M.	1962	Regional gravity survey, central and northern Australia 1959. Bur. Min. Resour. Aust. Rec. 1962/6 (unpubl.)

APPENDIX 1 - DETAILS OF WATER BORES

The sites of the bores listed below are shown on Plate 1. The information has been obtained from the Geological Branch of the Bureau of Mineral Resources (Mackay, 1957; Dunn 1962; Paine, 1962) and from the Water Resources Branch, NT Administration, Darwin.

Local Bore No.	Total depth (feet)	Yield (gal/hr)	Strata	Remarks
1	127	-	Sandstone overlying volcanics	Dry
2	75	Good	Sandstone	
3	87	-	Sandstone overlying volcanics	Dry
4	79	-	Sandstone overlying volcanics	Dry
5	222	1100	0-150 ft, Soil, clay, and boulders 150-215 ft, Limestone 215-222 ft, Gravel and sand	
6	110	1440	Limestone and sandstone	
7	41	-	0- 39 ft, Loam and clay 39- 41 ft, Hard basalt	Abandoned due to hard drilling
8	68	500	0- 32 ft, Brown shale 32- 68 ft, Sandstone	
9	181	2000	0- 55 ft, Clay 55-121 ft, Sandstone 121-181 ft, Limestone	
10	113	-	0-111 ft, Clay and limestone 111-113 ft, Volcanics	Abandoned due to hard drilling
11	52	-	? Volcanics	Dry
NA	171	950	0- 70 ft, Shale 70-171 ft, Sandstone	
NB	257	2100	0- 82 ft, Clay 82-257 ft, Limestone	
ND	420	2000	0- 52 ft, Clay and sandstone 52-395 ft, Hard basalt 395-420 ft, Sandstone	
555	250	1500	No information	
556	244	-	No information	
557	343	1500	No information	
1464	251	400	No information	
1465	352	700	No information	

APPENDIX 2 - ROCK DENSITIES

During April 1963, the author determined the densities of several rock samples that were collected in the vicinity of Nutwood Downs Station and which were on loan from the Geological Branch of the Bureau.

The densities are as follows:

BMR Sample No.	Age	Rock Type	Density g/cm^3
6005	Cretaceous	Sandstone (very porous)	1.75
6004	(?) Middle Cambrian	Tindall Limestone	2.72
6003	Lower Cambrian	Nutwood Downs Basalt	2.98
6027	Lower Cambrian	Bukalara Sandstone	2.23
6024	Upper Proterozoic	Siltstone, shale, and sandstone	2.51
6025	Upper Proterozoic		2.56
6011	Upper Proterozoic		2.50

APPENDIX 3 - OPERATIONAL DETAILS

Gravity meter

Worden No. 260

Calibration factor

0.10785 mgal/scale division

Determined on the Melbourne Calibration Range on 3rd August 1960

Method of traversing

A B C D A D E F ...

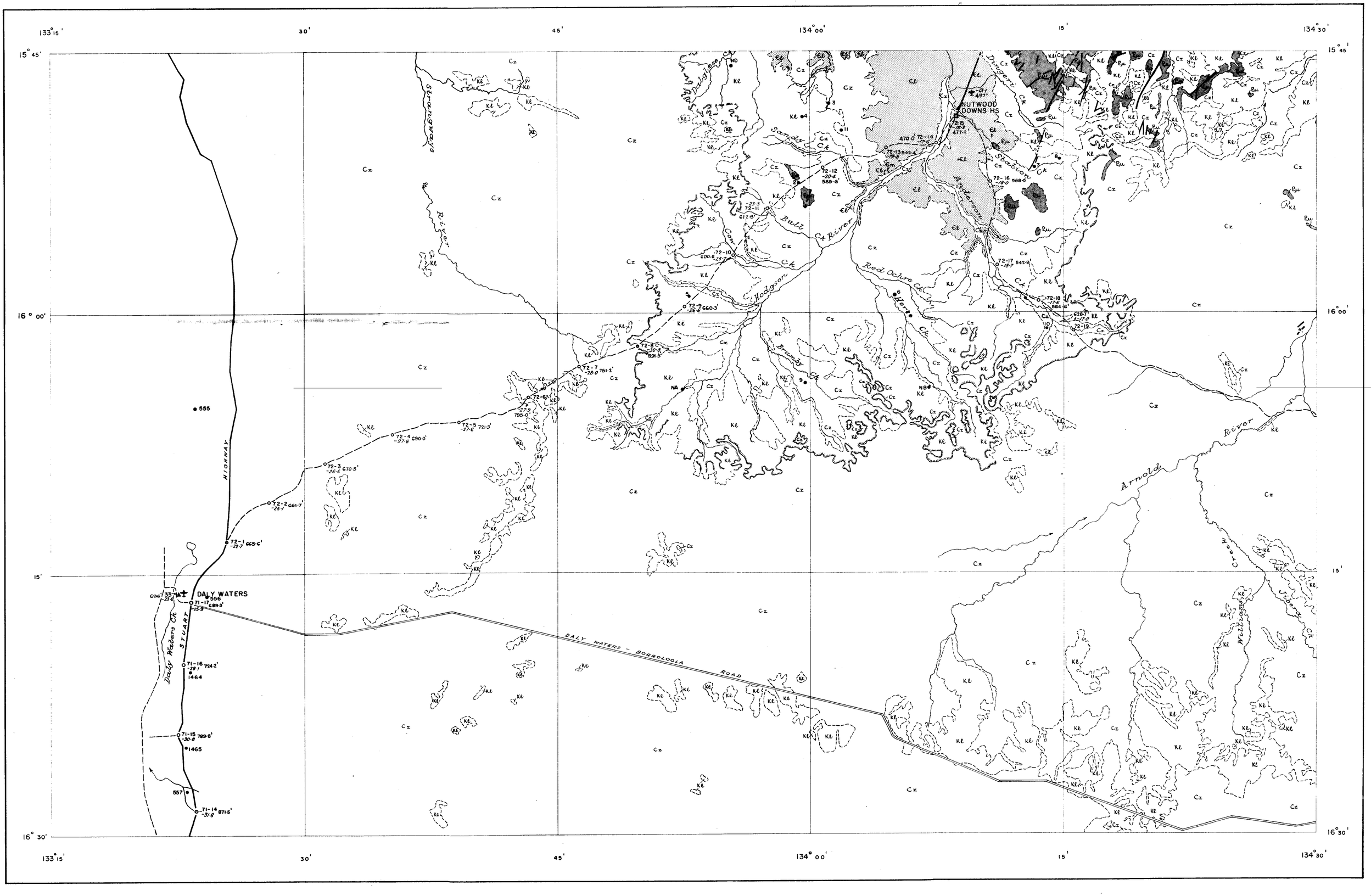
Surveying

Horizontal and vertical control by Department of the Interior surveyors using level and staff.

List of data files in Gravity Section, Geophysical Branch, Bureau of Mineral Resources

Field and drift sheets - 60,005

Computation sheets - 60,006



LOCATION

REFERENCE TO AUSTRALIA 1:250,000 MAP SERIES

LARRIMAH	HODGSON DOWNS
DALY WATERS	TANUMBIRINI

Bouguer anomalies are based on the observed gravity value of 978,388·5 milligals at BMR pendulum station N°33, Daly Waters

For the calculation of Bouguer anomalies 2·67 g/cm³ has been adopted as an average rock density

LEGEND

Cz	Cainozoic
Kℓ	Lower Cretaceous
€ℓ/€m	Lower Cambrian and Middle Cambrian
Pμ	Upper Proterozoic

Geology after BMR 1:250,000 geological series of Tanumbirini and Hodgson Downs.

	Geological boundary
	Fault
o	Gravity station
-15·2	Bouguer anomaly (milligals)
871·5	Elevation (feet)
▲	BMR pendulum station
	River or creek
	Road or track
	Escarpment
	Aerodrome
●7	Water bore
72-2	Survey peg number

REGIONAL GRAVITY SURVEY (1960)
DALY WATERS – NUTWOOD DOWNS, N T

BOUGUER ANOMALIES AND GEOLOGY

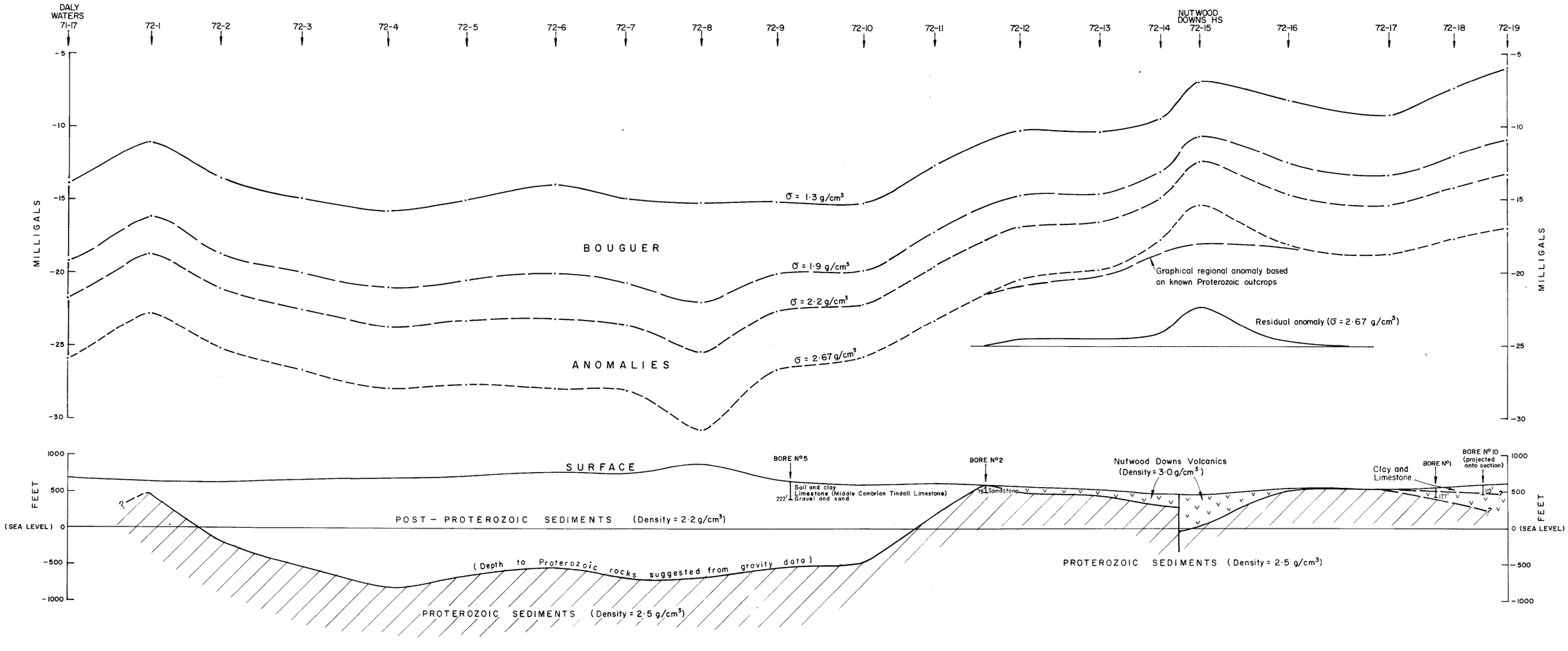
SCALE 1:250,000

5 0 5 10 15 MILES

To accompany Record No. 1963/136

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

E53/B2-17



Cross-section calculated using the layer formula

$\Delta g = 12{\cdot}77\,\rho h$

where Δg = gravity effect due to the upper layer

ρ = density contrast between the upper and lower layers

h = thickness of the upper layer in thousands of feet

σ = assumed density of near-surface sediments used to calculate the Bouguer correction

REGIONAL GRAVITY SURVEY (1960)
DALY WATERS - NUTWOOD DOWNS, NT

BOUGUER-ANOMALY PROFILES AND GEOLOGICAL INTERPRETATION

HORIZONTAL SCALE

5 0 5 10 MILES 15

Vertical scales as shown

TO ACCOMPANY RECORD NO. 1963/136

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E53/B2-18