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RECORD No. 1965/203

NORSEMAN DETAILED AEROMAGNETIC SURVEY, WA 1964, WITH AN INTERPRETATION OF DATA FROM A REGIONAL AEROMAGNETIC SURVEY, 1959

by

B.A. DOCKERY and W.A. FINNEY

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SUMMARY

A detailed aeromagnetic survey was made over an area of about fourteen square miles to the north-east of Norseman, WA, in August 1964 at the request of New Consolidated Gold Fields (Aust) Pty Ltd. The object of the survey was to aid geological mapping in the soil-covered portion of the area, and it was expected that detailed geological information would become available from the co-operating company and would enable an adequate interpretation to be made. Owing to delays in the company's programme, no detailed geological data were produced and therefore no significant interpretation of the results of the detailed survey was possible. However, the results of a Bureau of Mineral Resources regional aeromagnetic survey of 1959 have been examined more closely for a larger area and interpreted with the aid of recent geological information. The results in this Record are mainly derived from this interpretation.

At Norseman the rocks form the western limb of a regional anticline of Precambrian age and are divided stratigraphically into the Mount Thirsty Beds, the Abbotshall Beds, the Woolyeenyer Group, the Noganyer Group, and the Penneshaw Beds.

Two large amplitude anomalies are attributed to metajaspilite or ultrabasic beds within the Mount Thirsty Beds. The Abbotshall Beds cause an anomaly of moderate amplitude. The general magnetic expression of the Woolyeenyer Group is a featureless area of low magnetic field. A semicircular structure within the Woolyeenyer Group is the source of a zone of high magnetic field and warrants further investigation. The western limb of the anticline in the Noganyer Group shows up as a very large amplitude anomaly. It is suggested that the eastern limb of the Noganyer Group hybridized by the Eastern Granite, can also be traced in the magnetic pattern. The Penneshaw Beds might form the core of the regional anticline.

1. INTRODUCTION

During the first fortnight of August 1964, a detailed aeromagnetic survey was made over an area of about fourteen square miles north-east of Norseman (Plate 1). The survey was made at the request of New Consolidated Gold Fields (Aust) Pty Ltd, who held Temporary Reserves over the surveyed area, and was supported by the Geological Survey of Western Australia. The aim of the survey was to aid geological mapping in the soil-covered portion of the survey area.

Detailed geological information covering the survey area was expected to be produced by the co-operating company and to be available at the time the survey took place. However, delays in the company's programme prevented such information being obtained. No significant interpretation of the detailed aeromagnetic data is therefore possible.

Recent regional geological information for the Norseman area has become available from work done by Western Mining Corporation Ltd (Hall & Bekker, 1964), and this Record, although presenting the results of the detailed aeromagnetic survey, deals mainly with the interpretation of part of the results of a Bureau of Mineral Resources (BMR) regional aeromagnetic survey of the Norseman area in 1959 (BMR, 1965) in relation to this more recent geological information.

No other geophysical work is known to have been done in the survey area.

2. GEOLOGY

Norseman lies in the Dundas Goldfield of Western Australia and is about 100 miles south of Kalgoorlie. An account of the geology of Norseman was given by Campbell (1904), but very little has been published since this work. Two short articles were written by Ellis (1953) and O'Driscoll (1953). The most recent paper on the goldfield is by Hall and Bekker (1964), whose results are shown in Plate 1 and quoted and summarized in this section.

General geology

"Norseman lies near the southern end of a large mass of Precambrian greenstones and meta-sediments, which extends northward through Coolgardie and Kalgoorlie. This greenstone area is surrounded by the extensive granitic rocks of the Western Australian Precambrian Shield. The rocks at Norseman consist of sediment and basic lavas which strike NNE and dip uniformly west at about 55°, forming part of the west limb of a regional anticline which plunges flatly north. Basic and ultrabasic sills and dykes are numerous throughout the area which has also been intruded by a swarm of albite porphyry dykes. The rocks show a low to moderate degree of regional metamorphism.

The last phase of igneous activity was the intrusion of east-west trending doleritic and noritic dykes, the principal example being the Jimberlana Dyke.

Marine Tertiary and younger sediments occur on the lower-lying areas of the Precambrian surface, especially in the vicinity of the salt lakes."

Two types of gold mineralization are present in the field. Minor bedded quartz-sulphide lodes occur as replacements of folded or brecciated structures within the jaspilites (see below). The more important mineralization occurs as auriferous quartz reefs which strike approximately north and dip about 45° east. "Their main development occurs over a length of 7 miles in the stratigraphic zone which embraces the Crown-Bluebird sill sequence and the Mararoa Pillow Lava".

Precambrian rock succession

"The Archaean basic meta-igneous rocks and meta-sediments of the Norseman area have a fairly uniform dip to the west.

From the tope of the succession to the bottom, that is, from west to east in the field, the stratigraphic column is as follows:-

Name of Unit	Thickness (in feet)	Lithology
Western granite contact		
A. Mt. Thirsty Beds	25,000+	Slates, greywackes, quartzites, breccias, meta-jaspilites, meta-basaltic lavas and probably conformable ultrabasics.
B. Abbotshall Beds	800 to 4,500	Meta-jaspilites with interbedded basaltic rocks and clastic meta-sediments.
C. Woolyeenyer Group	28,000 to 32,000	
1. Desirable Pillow Lava	20,000 +	Meta-basaltic pillow lavas with minor graphitic slate members.
2. Crown Basalt	600	Multiple sill of massive alphanitic to strongly ophitic meta-basalt, with remnant bands of slate.
3. Nulsen Slate	3 to 6	Graphitic slate.
4. Royal Amphibolite	370 to 650	Complex sill of meta-quartz gabbro, meta-dolerite and remnant extrusive meta-basalts. Characterized by a weak schistosity and by the occurrence of small carbonate masses. 250 feet below the top of the formation occurs the Empress Slate Member (maximum thickness 10 feet).
5. Bluebird Gabbro	200 to 350	Sill of massive meta-quartz gabbro characterized by a coarsely porphyritic lower layer.

6.	Gee Cee Slate	½ to 6	Graphitic slate.
7.	Mararoa Pillow Lava	4,200	Meta-basaltic pillow lava.
8.	Venture Slate	3 to 10	Graphitic slate, sometimes partially replaced by quartz and dilated by intrusions of doleritic rocks.
9.	Kingswood Basalt	1,400	Meta-basaltic rocks, including pillow lavas
D.	Noganyer Group	4,500 +	A sedimentary sequence with well defined beds of meta-jaspilites, meta-conglomerates, sandstone, graphitic slate, biotite-andalusite schist, garnet-chlorite schist and mica schist. The Lady Mary Formation is a multiple sill of meta-gabbro and meta-dolerite.
E.	Penneshaw Beds	10,000 +	Meta-basaltic pillow lavas and other basic and acid metamorphic rocks.

Eastern Granite Contact"

3. RESULTS

The results of the survey are shown as a contour map of the total magnetic field intensity over the survey area (Plate 2). This map may be compared directly with the contour map of the total magnetic field intensity obtained from the BMR regional aeromagnetic survey of 1959 (BMR, 1965), part of which is shown in Plate 3.

From a comparison of the two contour maps it is apparent that the detailed survey has confirmed the results obtained by the regional survey and shows the various magnetic features in greater detail and greater contrast, but, because of the limited geological knowledge of the area within and adjacent to the detailed survey area, the results of the detailed survey contribute little to what was already apparent from the results of the regional survey.

A study of the regional aeromagnetic contour map shows that the main expression of the Mount Thirsty Beds is a large amplitude magnetic anomaly cutting the Jimberlana Dyke at approximately 121° 38' E and striking north-north-east. A parallel, large amplitude anomaly in the Mount Thirsty Beds cuts the Dyke about 3½ miles further east. Presumably these anomalies represent the major meta-jaspilite or ultrabasic beds of the Mount Thirsty Beds. Although not apparent on the contour map, low amplitude anomalies are present on the magnetic profiles over the Mount Thirsty Beds. These might be the

magnetic expression of the ultrabasic or meta-basaltic lavas, and the intermediate areas of low magnetic field might represent the areas of slate, greywacke, quartzites, and breccias.

Mount Thirsty Beds occur on the west limb of an anticline, which plunges gently north. The formation to the east of the Mount Thirsty Beds is the Abbotshall Beds of meta-jaspilite, which show up as a moderate amplitude anomaly on the contour map. An unusual feature is that the magnetic anomaly associated with these Beds occurs only over the parts of the Beds that crop out. Anomalies appear over the two islands in Lake Cowan that have been mapped as Abbotshall Beds, but not over the intermediate parts of the Beds that presumably underlie the Recent sediment in Lake Cowan. The most likely explanation is that the magnetic anomalies over the Beds are due to an ironstone capping over the exposed part of the Beds, and not to the unweathered rock existing at depth.

The magnetic expression of the Woolyeenyer Group south of the Jimberlana Dyke is a featureless area of low magnetic field. A study of the regional survey profiles for this area did not reveal any trends, although there were isolated low amplitude anomalies throughout. From a consideration of the lithology of the WoolyeenyerGroup, some magnetic trends were expected. In particular, the Royal Amphibolite and the Bluebird Gabbro were expected to contrast magnetically with the remainder of the Group. Such a feature might, however, be detected by a detailed magnetic survey in this region or in the vicinity of the Princess Royal Mine to the north of the Jimberlana Dyke.

A study of the profiles north of the Dyke revealed one trend in the Desirable Pillow Lava extending for five miles in a north to north-north-east direction from the point marked A in Plate 3. This might represent a more basic flow amongst the meta-basaltic pillow lavas of the Desirable Pillow Lava. A feature that occurs over what is presumed to be Desirable Pillow Lava is the semicircular zone of high magnetic field to the north of the peninsular that contains the Princess Royal Mine. An expression of the south-east end of this feature appears in the north-west corner of the detailed survey area. From a consideration of the lithology and magnetic characteristics over the known outcrop of the Desirable Pillow Lava, this semicircular feature must be due to an unidentified source within this formation. It is probably stratigraphically controlled, representing the north-pitching nose of the major anticline that affects the whole area discussed in this Record.

Four separate anomalies, B, C, D, and E, occur. The greatest amplitude is at D, which coincides with a small island in Lake Cowan. It seems likely that the magnetic anomalies might again be due to weathered ironstone cappings. If this is so, the anomaly of greatest amplitude could well mark an ironstone capping in outcrop, and the other three anomalies might arise from ironstone cappings now buried under lacustrine sediments.

The nature of the source of this semicircular magnetic feature warrants some investigation. It could be due to an untrabasic flow or a meta-jaspilite bed within the Desirable Pillow Lava, although no such beds have been described in the

lithology of this formation. Another possibility that could be of economic interest is that the source of the magnetic feature is a zone of sulphide mineralization emplaced into the nose of the major anticlinal structure. This possibility could be investigated by inspecting the island on Lake Cowan that coincides with anomaly D.

The most important formation economically, is the Crown-Bluebird sill sequence. From the lithological descriptions, a magnetic anomaly might be expected over this formation, but no such anomaly was detected by the regional survey. From the trend evident in Plate 1, the Crown-Bluebird sill sequence might cut across the north-west corner of the detailed survey area, but owing to practical limitations in the use of the magnetometer (see Appendix), a low amplitude magnetic feature striking north-east to east across the area would probably not have been detected in the detailed survey.

The Mararoa Pillow Lava and Kingswood Basalt are no more evident on the magnetic profiles than the other beds within the Wollyeenyer Group. Much of the contour map for the detailed survey is almost featureless, which would suggest that a large part of the detailed survey area (i.e. the north-western part, except for the extreme north-west corner) consists of the Woolyeenyer Group.

The large amplitude magnetic anomalies in the southern and south-western parts of the detailed survey area are attributed to the Noganyer Group. From a comparison of Plates 1 and 3 it is obvious that the Noganyer Group is strongly magnetic. There appears to be a discrepancy between Plates 1 and 3 where the magnetic data north of the Jimberlana Dyke indicate that the Noganyer Group extends half a mile to the north-west of the geological boundary as mapped in Plate 1.

South of the Jimberlana Dyke, the profiles of the regional survey show a north-trending magnetic 'high' at about longitude 121°54'. This is interpreted as being due to the Noganyer Group on the eastern limb of the major structural anticline, where it has been hybridized by the Eastern Granite. To test this proposition the large amplitude anomaly F should be investigated as there may be a xenolith of the Noganyer Group within the Eastern Granite at this point.

It is envisaged that the nose of the anticline in the Noganyer Group has been replaced by the Jimberlana Dyke, the magnetic 'high' at G representing a highly contorted off-shoot possibly having a tight fold of 180° in the bedding.

This interpretation implies that the Penneshaw Beds form the core of the anticline with the Eastern Granite contact falling along the axial plane of the anticline. The Penneshaw Beds are magnetically featureless on the regional contour map and are not within the area of the detailed contour map.

The area to the east of the Penneshaw Beds and south of the Jimberlana Dyke in Plate 3 is presumably mainly of Eastern Granite. North of this area and north of the Dyke, the geology is presumably a repetition on the eastern limb of the major anticline of the geology to the west. For example, the area of high magnetic field in the east of the detailed survey area may be due to a repetition of the Abbotshall Beds. There is an east-west lineation near Buldonia, which cannot be explained at present and the source of this feature may make the eastern limb of the anticline more contorted than the western limb.

Reference has been made above to the prominent anomalies over the Mount Thirsty Beds on the western limit of the anticline. The large amplitude anomalies near Buldonia, which strike north-west across the north-eastern corner of the area shown in Plate 3, could be the expression of part of the Mount Thirsty Beds occurring on the eastern limit of this anticline.

The Jimberlana Dyke is obvious in Plate 3 as a large amplitude anomaly which strikes east across the anticlinal structure described above and which corresponds approximately with the position mapped in Plate 1.

4. CONCLUSIONS

The magnetic characteristics of the various geological units have been determined from a comparison of the regional aeromagnetic results with the known geology. Also, from the regional aeromagnetic results, the major structure is seen as an anticline pitching flatly north with the axial plane at about the position of the contact between the Penneshaw Beds and the Eastern Granite. The eastern limb of the anticline, north of the Jimberlana Dyke, appears to be more contorted than the western limb. In particular, there is an east-west lineation near Buldonia, which cannot be explained at present. Geological mapping in this eastern section is needed to clarify the situation.

A semicircular magnetic feature in the Desirable Pillow Lava north of the peninsular that contains the Princess Royal Mine should be investigated further. It may be due to sulphide mineralization in the nose of the major anticlinal fold. As a first step, the island coinciding with anomaly D should be examined geologically to attempt to determine the nature of the underlying rock. It should be possible to delineate this feature more completely by means of detailed gravity and aeromagnetic surveys.

The detailed aeromagnetic survey was not successful in assisting the geological mapping within the survey area. It may have been far more useful if the survey area had included the peninsula that contains the Princess Royal Mine, as the Crown-Bluebird sill sequence may then have been detected and the known geology could have been used as a basis for the interpretation of the remainder of the survey area. Unfortunately, the geological map shown in Plate 1 was not available at the time of planning this survey. Also, owing to practical considerations, it may not have been possible to detect the low amplitude anomaly expected over the Crown-Bluebird sill sequence.

The source of the large amplitude anomaly F should be investigated because it may be due to a xenolith of the Noganyer Group within the Eastern Granite. If this were so, it could be confidently proposed that the eastern limb of the Noganyer Group has been hybridized by the Eastern Granite and is now represented by a magnetic 'high' along longitude 121° 54' E.

5. REFERENCES

BMR 1965 - Maps showing the results of an airborne magnetic and radiometric survey of the Norseman 1:250,000 area. Bur.Min.Resour.Aust.Rec. 1965/36.

CAMBELL, W.D., 1904 - The geology and mineral resources of the Norseman district. Geol.Surv.W.A. Bull.21.

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HALL, H.I.E., and BEKKER, C., 1964 - The gold deposits of Norseman, Western Australia. Paper presented to 1964 Annual Conference of the Australian Institute of Mining and Metallurgy.

O'DRISCOLL, D., 1953 - Operations on the Norseman Field. In GEOLOGY OF AUSTRALIAN ORE DEPOSITS. Aust.Inst. Min.Metall.

APPENDIX

Operational details

Survey specifications

Detector altitude	:	250 feet above ground level
Line spacing	:	One tenth of a mile between adjacent flight lines
Line direction	:	Parallel to Eyre Highway, that is, approximately 077°
Recorder sensitivity	:	1st recorder, 20 gammas per inch 2nd recorder, 2000 gammas per inch
Diurnal correction	:	Applied correction rounded off to the nearest gamma

Equipment

Aircraft	:	Cessna 180
Magnetometer	:	BMR proton precession type MNS1
Recorder	:	2 x Mosely Autograph 1 x Texas Instruments (two-channel)
Camera	:	Modified Vinten frame, 35 mm, 186° field of view
Radio altimeter	:	AN/APN-1

Method

A correction for diurnal variation was determined by flying a baseline at the beginning and end of each survey flight. The mean level of the magnetic field readings obtained along the baseline was compared with a standard level to determine the correction. The diurnal correction was applied on the assumption that the diurnal magnetic field varied in a linear manner during any one survey flight. No total magnetic field recorder was available to check this proposition.

Notification of magnetic storms was given by BMR Mundaring Observatory.

The airborne magnetometer records accepted for survey data showed a noise envelope of approximately 20 gammas. This high noise level limited the detection of low amplitude anomalies. Also, it imposed a limitation on the direction of the flight lines, which had to be in an easterly direction for minimum noise, whereas flight lines in directions between north-west and north would have been preferred.

No samples of rocks were collected during the survey. Thus no measurements were made of either magnetic susceptibility or remanent magnetization.

Personnel

Personnel engaged in the survey were:

BMR: B.A. Dockery, W.A. Finney, A.S. Scherl, P. Zerial
C.J. Braybrook, B. Tregallas.

T.A.A. : First Officer G.B. Litchfield.

PLATE I

LAKE COWAN

LAKE COWAN

LAKE DUNDAS

LAKE DUNDAS

NORSEMAN

121° 40'

122° 00'

32° 05'

32° 25'

50

55

20

EYRE HIGHWAY

N

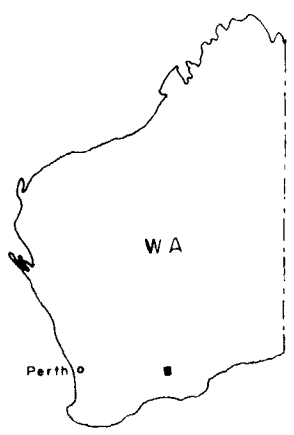
(1) CROWN REEF
(2) BLUEBIRD REEF
(3) MARAROA REEF
(4) NORSEMAN - NORTHERN STAR REEF
(5) LADY JEAN - VALKYRIE REEF
(6) MT. BARKER - HINEMUA REEF
(7) PRINCESS ROYAL REEF
(8) OK REEF
(9) CUMBERLAND REEF
(10) LADY MILLER MINE

MT. THIRSTY BEDS
ABBOTSHALL BEDS
DESIRABLE PILLOW LAVA
CROWN - BLUEBIRD SILL SEQUENCE
MARAROA PILLOW LAVA & KINGSWOOD BASALT
NOGANYER GROUP
PENNESHAW BEDS
GRANITE
JIMBERLANA DYKE
FAULTS
REEF CHANNELS

DETAILED AEROMAGNETIC SURVEY BOUNDARY

Geological and planimetric mapping from paper "The Gold Deposits of Norseman, WA" by H.I.E. Hall and C. Bekker, 1964

LOCATION DIAGRAM



DETAILED AEROMAGNETIC SURVEY, 1964

NORSEMAN

WESTERN AUSTRALIA

LOCALITY MAP AND REGIONAL GEOLOGY

TOPOGRAPHY

Highway
Railway

MILES 0 1 2 3 4 5 6 7 MILES

KILOMETRES 0 1 2 3 4 5 6 7 8 9 10 KILOMETRES

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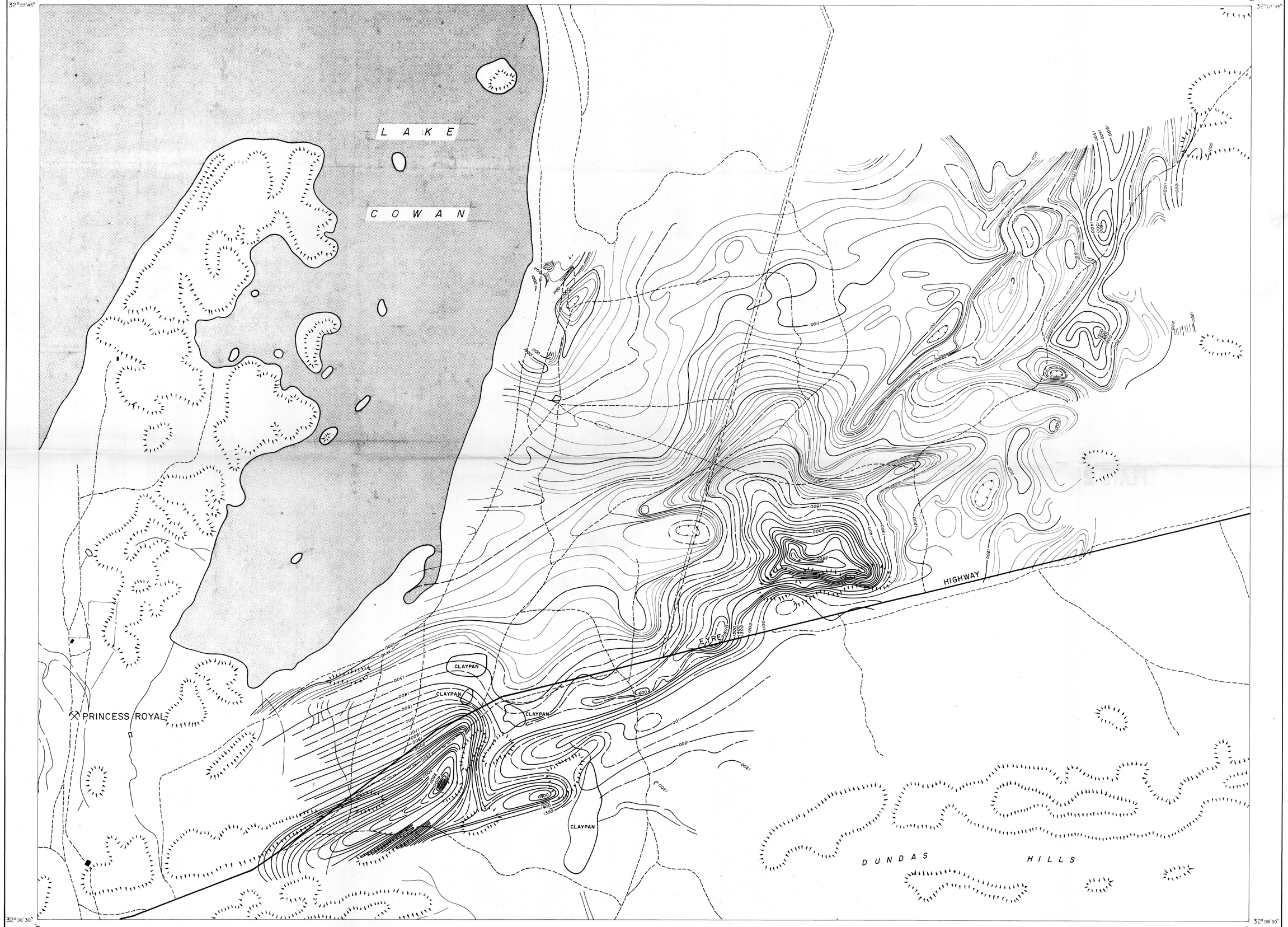
PLATE 2

121° 48'
32°09'45"
121° 57'
32°09'45"



32°08'30"
121° 48'
121° 57'
32°08'30"

DETAILED AEROMAGNETIC SURVEY, 1964

NORSEMAN

WESTERN AUSTRALIA

TOTAL MAGNETIC INTENSITY CONTOURS

True North
Mag. North

MILES 0 MILES

KILOMETRES 0 KILOMETRES

MAGNETIC CONTOUR INTERVAL 10 GAMMAS

GEOPHYSICAL LEGEND

Magnetic contours

Magnetic "Low"

NOTE :- The magnetic data have not been corrected for the regional magnetic gradient.

TOPOGRAPHICAL LEGEND

- River or creek
- Highway or main road
- Road or track
- Fence
- Hill feature
- Mine
- Dam
- Hut

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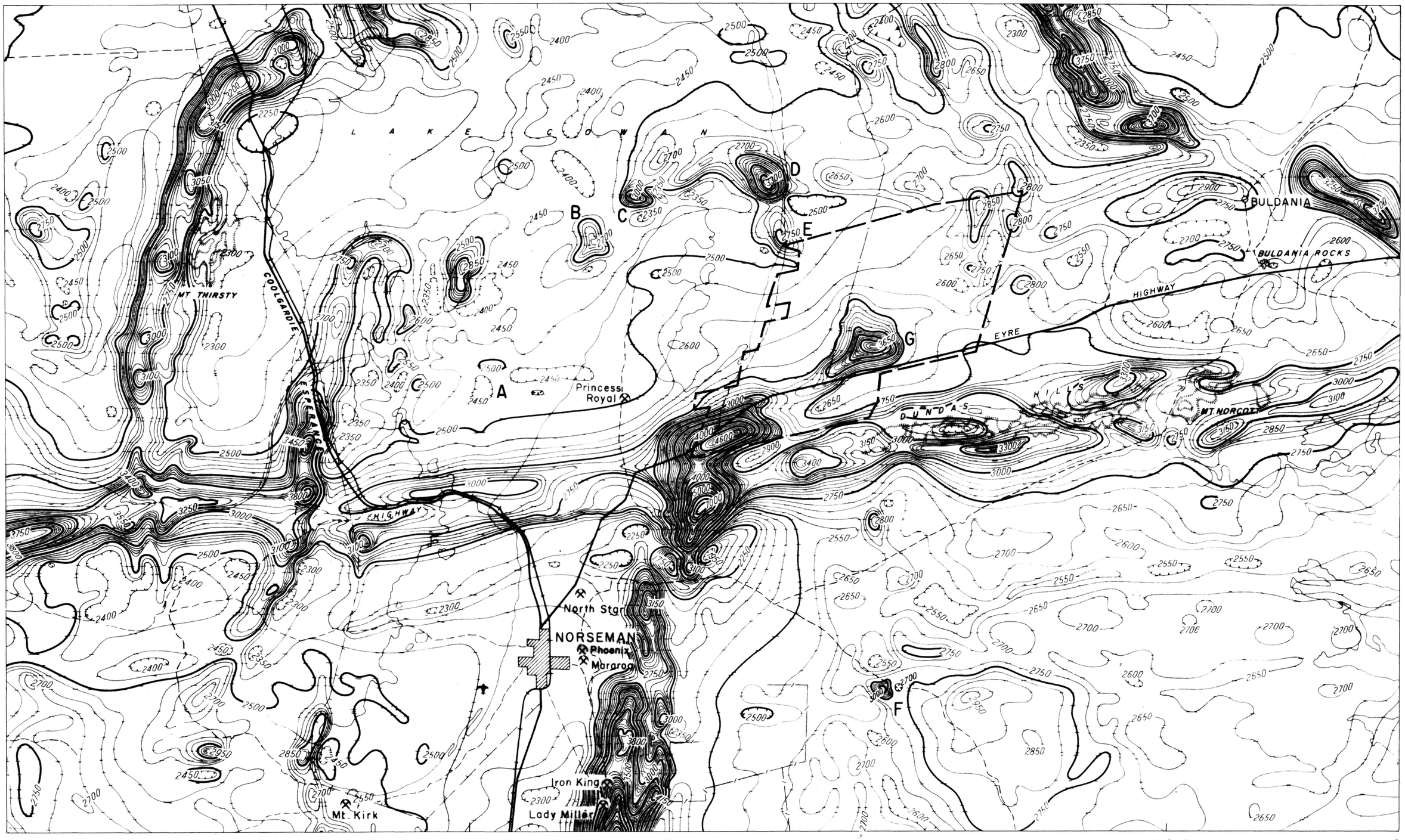
To Accompany Record No. 1965/203

PLATE 3

121° 35' 45' 122° 00' 122° 05'

32° 00'

32° 15'



THIS MAP IS PART OF B.M.R. AEROMAGNETIC MAP OF NORSEMAN 1:126,720 N.W. SHEET G334-10.

MAGNETIC DATA

- Magnetic contours
- Magnetic Low
- Contour/Flight line intersections
- Boundary of 1964 detailed aeromagnetic survey
- A — Magnetic features (for text reference only)

MAG. & TRUE NORTH

REGIONAL AEROMAGNETIC SURVEY, 1959

NORSEMAN

WESTERN AUSTRALIA

TOTAL MAGNETIC INTENSITY CONTOURS

MILES 2 0 2 4 6 8 10 MILES

KILOMETRES 0 5 10 KILOMETRES

MAGNETIC CONTOUR INTERVAL 50 GAMMAS

TOPOGRAPHICAL DATA

- River or Creek
- Highway or Main road
- Road or Track
- Railway
- Fence
- Rock outcrop
- Named place
- Hill feature
- Aerodrome or landing ground
- Mine

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