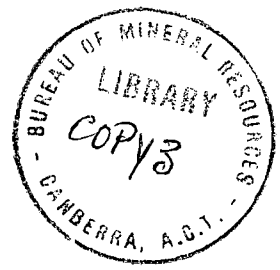
COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1970 / 57

Gosses Bluff Airborne Magnetic Survey, Northern Territory 1968



by

G.A. Young

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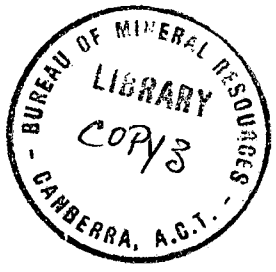

by

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SUMMARY

An airborne magnetic survey of an area of 580 square kilometres centred on Gosses Bluff was flown in 1968. This survey formed part of a joint project by the Bureau of Mineral Resources and the United States Geological Survey to determine the detailed structure of Gosses Bluff and to evaluate the hypothesis that the Bluff is of impact origin.

Analyses of the magnetic data show that shallow sources of magnetic disturbance flank the Bluff on its southern side. Interpretation of these magnetic anomalies indicates their source to be shock-melted breccias of possible Jurassic age.

1. INTRODUCTION

In November 1968 the Bureau of Mineral Resources, Geology & Geophysics (BMR) made a detailed aeromagnetic survey of an area of 580 square kilometres centred on Gosses Bluff (Plate 1). This survey formed part of a joint project of geological and geophysical investigations by the Bureau of Mineral Resources and the Astrogeological Studies Group of the United States Geological Survey, commenced in 1967.

Gosses Bluff is a large, circular structure located approximately 160 kilometres west of Alice Springs, Northern Territory. It is formed by a circular range about 5 kilometres in diameter, which rises approximately 250 metres above the surrounding plains. This encircling range encloses a pound 2 kilometres in diameter which is slightly elevated above the outside plain.

One of the first geological investigations of Gosses Bluff was made by the Bureau of Mineral Resources in 1956 (Prichard & Quinlan, 1962). Since that time, further geological investigations have been made of this structure, e.g. by Brunnschweiler (1959), Crook and Cook (1966), and Glikson (1969). As a result of these investigations, an early theory that the structure was due to a diapir has been discarded in favour of a hypothesis that the structure was formed either by a volcanic explosion or by impact from an extra-terrestrial body.

Extensive geophysical surveys directed towards petroleum search have been made in the vicinity of Gosses Bluff. In general these surveys have been of a regional nature designed to investigate the overall structure of the Amadeus Basin. They include a regional gravity survey by Lonsdale and Flavelle (1963), a regional airborne magnetic and radiometric survey made by Young and Shelley (1966), and numerous seismic surveys. Of the latter, seismic surveys by Moss (1964) and Magellan Petroleum (1965) were designed to give detailed information of the underlying structure of the Bluff. To test the hypothesis that Gosses Bluff might be the surface expression of a salt dome the Gosses Bluff No. 1 bore was drilled in 1965, but it did not penetrate any salt.

Plate 2 shows seismic traverses, well sites, and Bouguer anomaly contours in the general area around Gosses Bluff. The Bouguer anomaly contours are derived from the regional survey by Lonsdale and Flavelle (op. cit.) supplemented by the more detailed survey by Magellan Petroleum (op. cit.). Plate 3 shows basement depths and structure determined by Young and Shelley (op. cit.) from their regional aeromagnetic data.

As most of the geophysical data collected before this survey indicated that the Gosses Bluff structure has little or no expression in the crystalline basement, the object of this survey was to investigate near-surface magnetic effects of the strata composing the Bluff. Chapter 3 of this Record, which deals with the magnetic results and interpretation, details the survey design required to measure the small magnetic anomalies which were expected.

2. GEOLOGY

Gosses Bluff is situated near the northern margin of the Amadeus Basin in the middle of the Missionary Plains Synclinorium. The total sedimentary thickness at this locality is interpreted by Crook and Cook (1966) to be in excess of 10,000 metres, made up as follows:

Age	Formation	Thickness, metres
Quaternary Tertiary ?Mesozoic	Conglomerate, sandstone* and siltstone	150
?Carboniferous-Devonian	PERTNJARA GROUP* - conglomerate, poorly sorted sandstone, some siltstone	3000-4500
Devonian-Late Ordovician	MEREENIE SANDSTONE* - clean, cross-bedded sandstone at the top with some red-brown sandstone at the base	300-600
Late Ordovician - Late Cambrian	LARAPINTA GROUP* - consists of (in descending order) - Carmichael Sandstone, Stokes Siltstone*, Stairway Sandstone*, Horn Valley Siltstone, and Pacoota Sandstone	1500
Cambrian	PERTAOORRTA GROUP - numerous formations - mainly sandstone and siltstone with minor limestone and dolomite and possibly thin salt interbeds near the base	1500
Adelaidean	PERTATATAKA FORMATION - siltstone with minor dolomite and limestone	600
	AREYONGA FORMATION - tillitic sediments	300
	BITTER SPRINGS FORMATION - carbonates, siltstone and salt, some volcanics in places	600+
	HEAVITREE QUARTZITE - sandstone with minor siltstone	300
Archaean	ARUNTA COMPLEX - Schist, gneiss, granite, etc.	

* Asterisk indicates that the formation is exposed at Gosses Bluff. All other formations are probably present below the surface.

Plate 5 shows the surface geology in the vicinity of the Bluff, as most recently mapped (Glikson, 1969). The core of the structure consists in general of steeply dipping and highly faulted shale, sandstone, and limestone of the Larapinta Group. The upstanding rim of the Bluff comprises sandstones of the Mereenie and Pertnjara Formations, which also dip steeply.

This structure is bilaterally symmetrical about a north-south axis, but the northern and southern halves are quite different. Glikson's detailed geological map suggests that in the north the faults tend to run roughly north-south in the Stokes Siltstone and Pertnjara Group, and east-west in the Carmichael Sandstone and Mereenie Sandstone; in the south the pattern is reversed: the faults in the Stokes and Pertnjara run roughly east-west, and in the Carmichael and Mereenie north-south.

Cook (1968) suggests that flanking the Bluff itself is an annulus of breccia at least 5 kilometres wide and possibly more than 150 metres thick. At Mount Pyroclast, 3 kilometres south of Gosses Bluff, shock-melted breccia crops out.

The circular structure terminates at distances ranging between 6 and 11 kilometres from the centre of Gosses Bluff. The boundary between the deformed and the relatively undisturbed strata of Missionary Plain appears to be abrupt.

3. MAGNETIC RESULTS AND INTERPRETATION

The total magnetic intensity contours for the locality about Gosses Bluff, produced from the Amadeus Basin airborne survey (Young & Shelley, 1966), are shown in Plate 4. These contours, derived from a series of east-west flight-lines flown at an altitude of approximately 300 metres above ground level, indicate that no near-surface magnetic anomalies were recorded. However, during the course of the above mentioned survey, a test flight at lower altitudes about Gosses Bluff revealed small negative anomalies of amplitude 2 to 4 gammas on the southwest flank of the structure.

Plate 1 illustrates the flight-line pattern which was flown in November 1968 to examine in detail any near-surface magnetic anomaly associated with the structure. Plates 5 and 6 show respectively the resultant residual and digitally filtered magnetic fields in areas where such anomalous fields exceed $\pm$ 1 gamma.

Both Plates 5 and 6 illustrate the most important characteristic of the magnetic results, namely the negative anomaly form of very short wavelength. This is indicative of very near-surface magnetic anomalies, the main component of magnetisation being remanent and in opposition to the earth's present field.

The association of the intense, localised negative anomaly with Mount Pyroclast is interpreted as representing remanent magnetisation of shock-melted breccia. Similar magnetic anomalies which in part ring the southern flank of Gosses Bluff are interpreted as being produced by an identical rock type.

A magnetic model study of the anomaly recorded on line 5 over Mount Pyroclast is shown in Figure 1. This anomaly is interpreted as being produced by a magnetic dipole inclined at $+85^{\circ}$ lying in the magnetic meridian.

As a magnetised sphere exhibits the same magnetic field as a dipole located at its centre, the Mount Pyroclast anomaly is interpreted as being due to a near-spherical mass of shock-melted breccia whose centre is located 100 metres below ground level. Furthermore, this interpretation leads to the hypothesis that the anomalous body is now magnetised in the same direction as the palaeomagnetic field that existed immediately after the formation of the Gosses Bluff structure.

This hypothesis is supported by the magnetic model study of the anomaly recorded on line 14 over the rim of the Bluff itself, assuming source rocks with similar remanent magnetisation. Figure 2 illustrates the remarkable agreement between the observed magnetic anomaly and that for a thin sheet-like body with width less than 105 metres, upper surface 90 metres below ground level, and lower surface 270 metres below ground level. The strike of this body is N 100° E as interpreted from the magnetic data and its dip is assumed to be 80°S as indicated by neighbouring geological information.

It is appropriate to conclude that the inclination of the Earth's magnetic field was +85° immediately after the formation of the Gosses Bluff structure. This is equivalent to a palaeolatitude of 80°S for Gosses Bluff at that time, which would represent a palaeolatitude at Canberra of 83°S. Figure 3 shows palaeolatitudes calculated for Canberra by Irving (1964); it shows that Canberra's palaeolatitude was 70°S or greater from Carboniferous to Cretaceous time, and reached a maximum near 80°S in Jurassic time.

4. CONCLUSIONS AND RECOMMENDATIONS

The results from this survey have revealed magnetic anomalies associated with near-surface rocks of the Gosses Bluff structure. The construction of residual and digitally filtered magnetic contours clearly defines the character of the magnetic anomalies due to near-surface rocks. In general, both data presentations reveal an east-west symmetry about the centre of Gosses Bluff. However, no such north-south symmetry exists: magnetic anomalies are absent from the north of the structure. The anomalies have been interpreted as being produced by shock-melted breccia of the type that crops out at Mount Pyroclast; furthermore, a Jurassic age is suggested for the structure.

It is desirable to make ground magnetic surveys over Mount Pyroclast and immediately south of the rim of the Bluff to determine magnetic anomaly form and source rock location more exactly. This would allow drilling targets to be selected in both of these locations to provide samples of the anomalous source rocks.

Both geological and palaeomagnetic studies should be made on any rock samples so obtained, to date the structure more accurately. In addition, analyses will be required to determine whether the rocks contain any extra-terrestrial material which may in part account for the very localised magnetic disturbance.

5. REFERENCES

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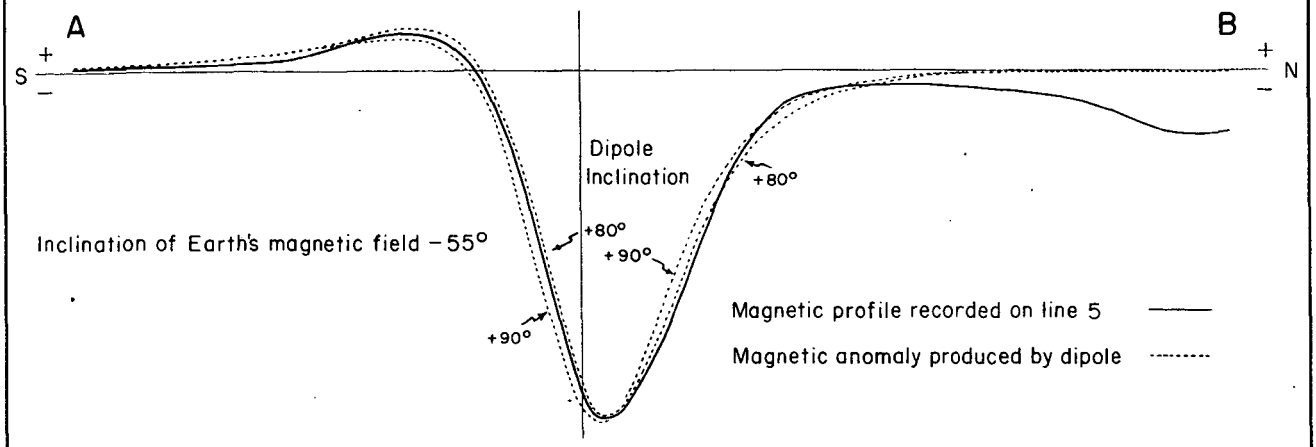


Figure 1. INTERPRETATION OF MAGNETIC ANOMALY RECORDED ON LINE 5

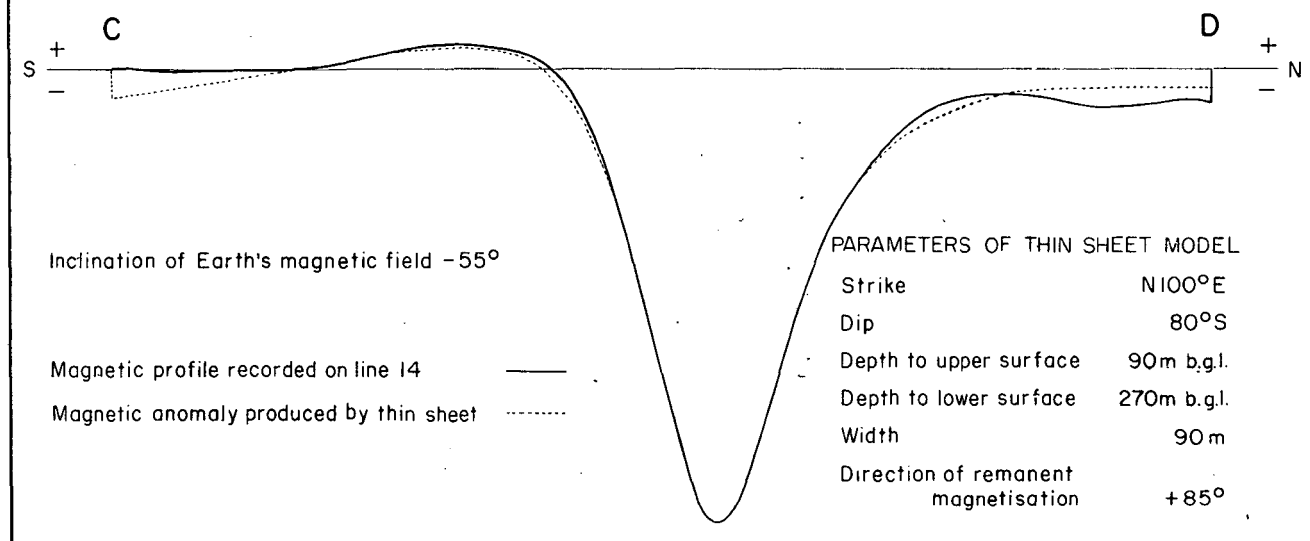


Figure 2. INTERPRETATION OF MAGNETIC ANOMALY RECORDED ON LINE 14

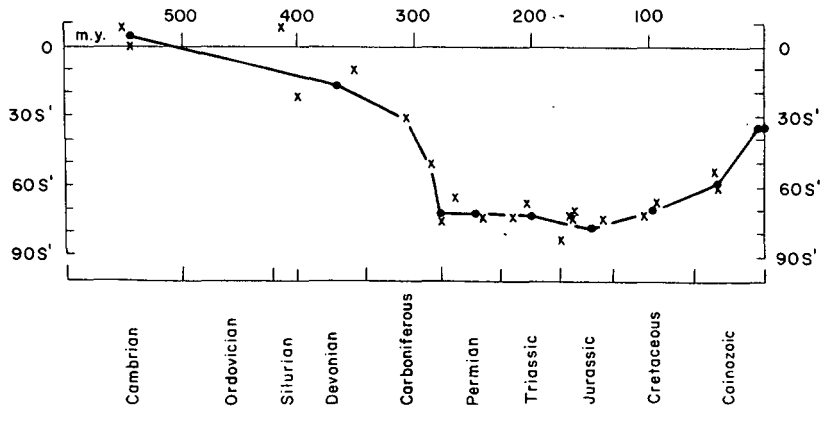
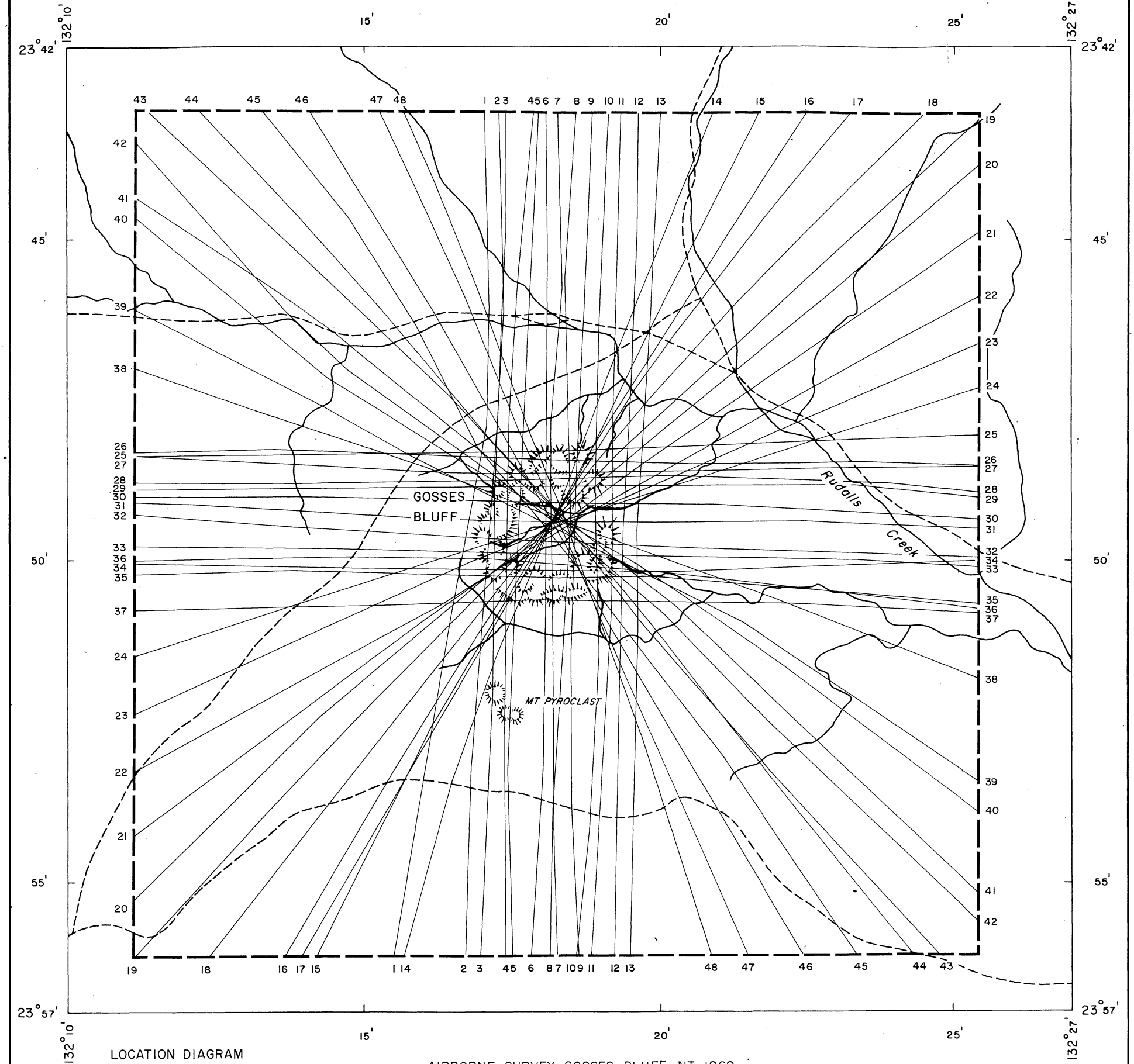


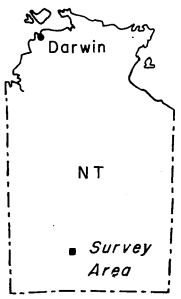
Figure 3. PALAEOLATITUDE TIME VARIATIONS FOR CANBERRA

(FROM IRVING 1964)

PLATE 1



LOCATION DIAGRAM



(BASED ON F53/BO-53)

AIRBORNE SURVEY, GOSSES BLUFF, NT 1969

LOCALITY MAP
SHOWING
FLIGHT - LINES

2 0 2 4 6 MILES

5 0 5 KILOMETRES

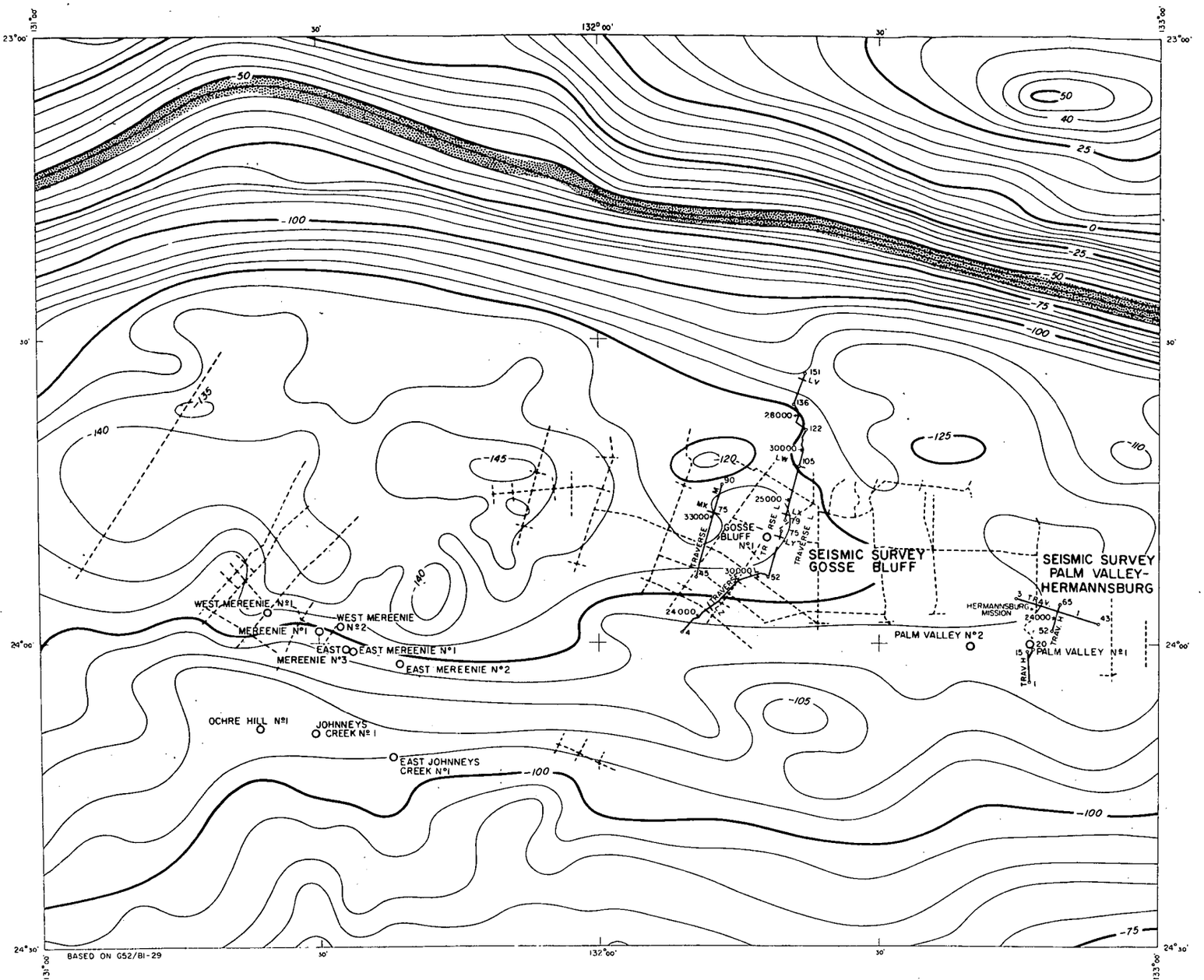
LEGEND

22 Flight-line and number

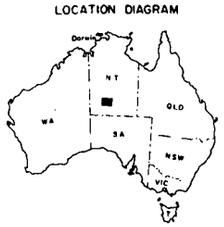
Survey boundary

F53/BL-86

TO ACCOMPANY RECORD No. 1970/57



LOCATION DIAGRAM



AIRBORNE SURVEY, GOSSES BLUFF, NT 1968

GRAVITY, SEISMIC AND WELL DATA

LEGEND

-70 Gravity contour Interval 5 milligals

Boundary of gravity feature

47 72 1000 Seismic traverse (BMR) with shot-point locations Minimum depth to crystalline basement below sea level

Seismic survey, private company

Well

10 0 10 20 30 40 MILES

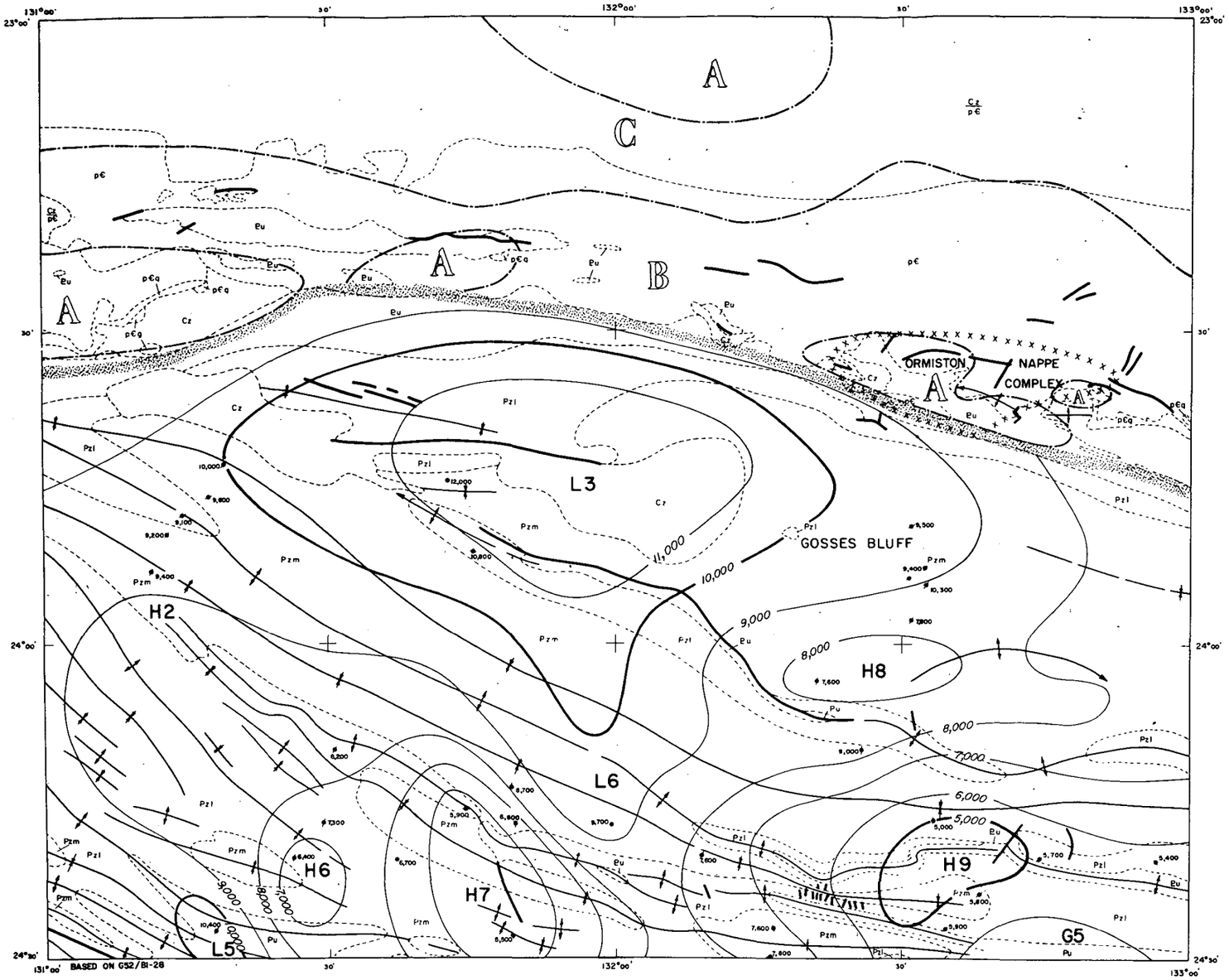
10 0 10 20 30 40 50 60 KILOMETRES

INDEX TO 1:250,000 SHEETS

LAKE MACKAY	MT DOREEN	NAPPERBY	ALCOOTA
MOUNT RENNIE	MOUNT LIEBIG	HERMANNSBURG	ALICE SPRINGS
BLOODS RANGE	LAKE AMADEUS	HENBURY	RODINGA

F52/81-33

TO ACCOMPANY RECORD No. 1970/57



GEOLOGICAL LEGEND

AGE		SYMBOLS	ROCK UNITS			OROGENIC EPISODE
CAINOZOIC		Cz				
MESOZOIC		M	Rumbalara Shale De Souza Sandstone Undifferentiated			
PALAEOZOIC	PERMIAN	Pzu	Crown Point Formation Buck Formation Undifferentiated			
	CARBONIFEROUS					Alice Springs Orogeny
	DEVONIAN	Pzm	? Ligertwood Beds Pertnjara Group	Finke Group		
						Pertnjara Movement
	SILURIAN		Mereenie Sandstone			
		?				Rodingan Movement
	ORDOVICIAN	Pzl	Larapinta Group			
	CAMBRIAN		Pertaoorrta Group	Cleland Sandstone	Mount Currie Conglomerate -and Ayers Rock arkose	
						Petermann Ranges Orogeny
PRECAMBRIAN	UPPER PROTEROZOIC	Pu	Pertatataka Formation	Winnall Beds	Maurice Formation Sir Frederick Conglomerate Ellis Sandstone Carnegie Formation	
			'Areyonga Formation	Inindia Beds	Boord Formation	
			Bitter Springs Formation Heavitree Quartzite	Pinyinna Beds Dean Quartzite	Bitter Springs Formation Heavitree Quartzite	
	UNDIFFERENTIATED	p€(1)		Bloods Range Beds Mount Harris Basalt	Undifferentiated volcanics and low grade metasediments	
		p€(2)		Olia Gneiss and metasediments		
		p€	Arunta Complex	Moderate grade gneiss, metasediment, gneissic granite		? Arunta Orogeny
		p€q	Quartzite			
IGNEOUS		p€g	Granite			Formed during Petermann Ranges and Arunta Orogenies? Alice Springs Orogeny

LEGEND FROM BMR STRUCTURE & MAGNETIC BASEMENT CONTOUR MAP, AMADEUS BASIN NT/A/297 (a)

- Geological boundary
- Plunge of anticline
- Plunge of syncline
- Fault
- xxxxxx Nappe boundary

LOCATION DIAGRAM

INDEX TO 1:250,000 SHEETS

LAKE MACKAY	MT DOREEN	NAPPERBY	ALCOOTA
MOUNT RENNIE	MOUNT LIEBIG	HERMANNS-BURG	ALICE SPRINGS
BLOODS RANGE	LAKE AMADEUS	HENBURY	RODINGA

AIRBORNE SURVEY, GOSSES BLUFF, NT 1968

MAGNETIC INTERPRETATION

AND

TECTONIC GEOLOGY

10 0 10 20 30 40 MILES

10 0 10 20 30 40 50 60 KILOMETRES

GEOPHYSICAL LEGEND

- Basement depth estimate corrected for magnetic strike
- Basement depth estimate uncorrected
- 10,000 Basement depth contour

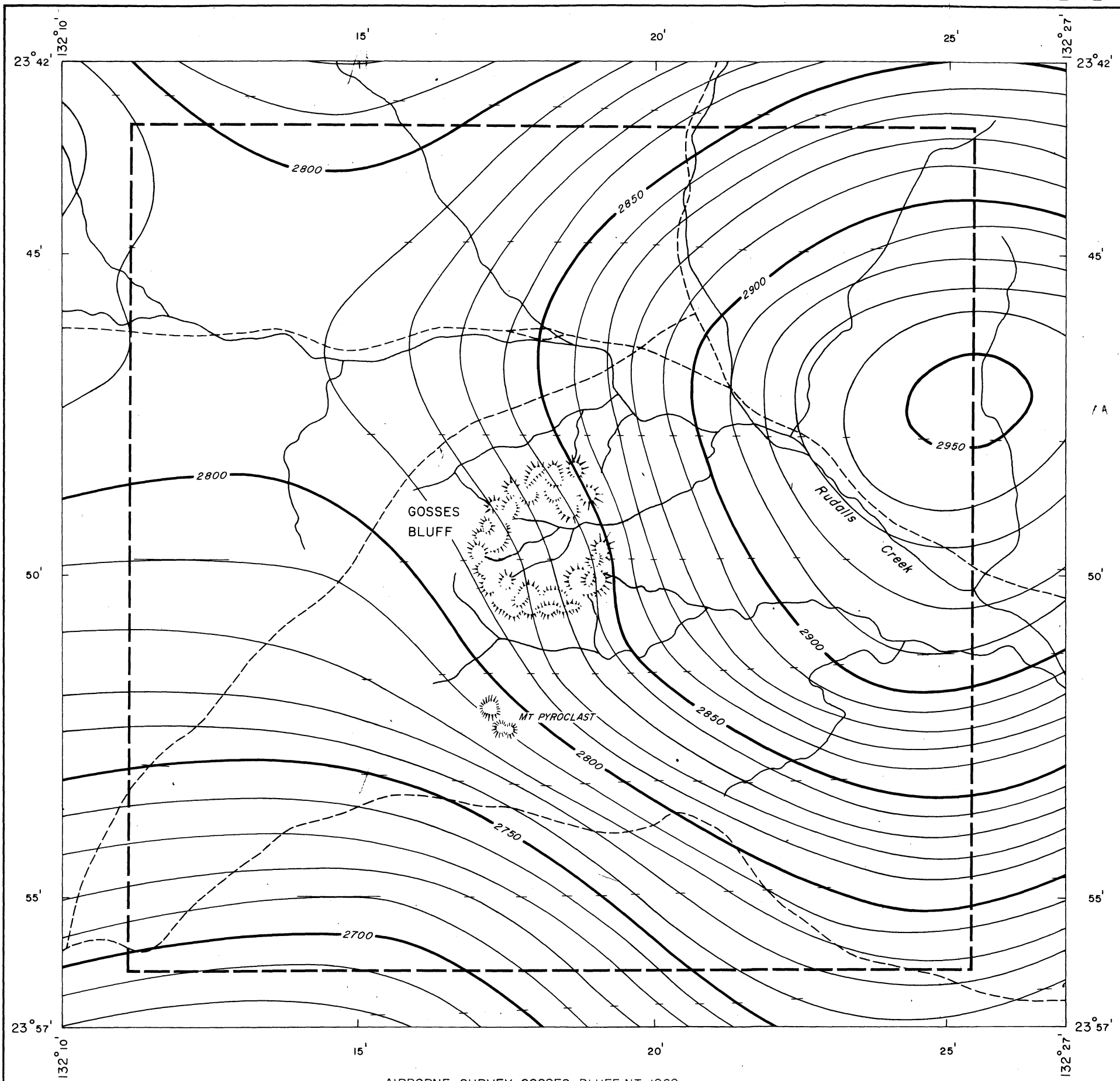
} Depth in metres Below sea level

- A Basement zone and zone boundary
- Basin boundary magnetically inferred
- Fault
- H2 L3 G4 Magnetic basement features

NOTE: THE MAGNETIC INTERPRETATION HAS BEEN DERIVED FROM THE BMR AIRBORNE SURVEY, AMADEUS BASIN, NT, 1965 (BMR Record No. 1966/230)

F52/BI-32

TO ACCOMPANY RECORD No. 1970/57



AIRBORNE SURVEY, GOSSES BLUFF, NT 1969

TOTAL MAGNETIC INTENSITY

DERIVED FROM BMR AIRBORNE SURVEY
AMADEUS BASIN NT 1965

2 0 2 4 6 MILES

5 0 5 KILOMETRES

CONTOUR INTERVAL 10 GAMMAS

LEGEND

- Magnetic contours
- Contour/flight-line intersections
- 1968 survey boundary

(BASED ON F53/BO-53)

F53/B1-87

TO ACCOMPANY RECORD No. 1970/57

PLATE 5

132°14'30"
132°22'30"
23°47'30"
23°53'30"
15'
20'
50'

GOSSES BLUFF

Rudolis Creek

Flight-line 14
Flight-line 5
A
B
C
MT PYROCLAST

AIRBORNE SURVEY, GOSSES BLUFF, NT 1968

TOTAL MAGNETIC INTENSITY RESIDUAL ANOMALIES AND GEOLOGY

1:25,000
0 2 MILES
0 2 KILOMETRES

CONTOUR INTERVAL 1 GAMMA

TOPOGRAPHICAL LEGEND

- Road or track
- Creek
- Hill feature

GEOPHYSICAL LEGEND

- Magnetic contours

NOTE

GEOLOGY AFTER SKETCH MAP (F53/A13/28)
BY D.J MILTON, R.BRETT & A.Y.GLIKSON

GEOLOGICAL LEGEND

- Surface deposits
- Breccia – impact
- Breccia – flow
- Pertnjara Group
- Mereenie Sandstone
- Larapinta Group
- Geological boundary

F53/B1-99

BASED ON F53/80-55, F53/B1-94, F53/B1-92, F53/B1-97

TO ACCOMPANY RECORD No. 1970/57

132°14'30" 15' 20' 132°22'30"

23°47'30"

50'

Rudalls Creek

GOSSES BLUFF

MT PYROCLAST

23°53'30"

AIRBORNE SURVEY, GOSSES BLUFF, NT 1968

TOTAL MAGNETIC INTENSITY FILTERED ANOMALIES AND GEOLOGY

1:25,000

0 2 MILES

0 2 KILOMETRES

CONTOUR INTERVAL 1 GAMMA

TOPOGRAPHICAL LEGEND

- Road or track
- Creek
- Hill feature

GEOPHYSICAL LEGEND

- Magnetic contours

NOTE

GEOLOGY AFTER SKETCH MAP (F53/A13/28) BY D.J. MILTON, R. BRETT & A.Y. GLIKSON

THE FILTER APPLIED TO THE MAGNETIC DATA HAS A WAVELENGTH OF 1·2 KILOMETRES

GEOLOGICAL LEGEND

- Surface deposits
- Breccia — impact
- Breccia — flow
- Pertnjara Group
- Mereenie Sandstone
- Larapinta Group
- Geological boundary

F53/BI-98

BASED ON F53/BO-55, F53/BI-94, F53/BI-93, F53/BI-97

TO ACCOMPANY RECORD No. 1970/57