DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS:

RECORD NO. 1968/4

MERREDIN-PERTH AIRBORNE MAGNETIC AND RADIOMETRIC TRAVERSES FOR UPPER MANTLE PROJECT.

WESTERN AUSTRALIA 1966

by

D.B. TIPPER

5928/65

RECORD NO. 1968/4

MERREDIN-PERTH AIRBORNE MAGNETIC AND RADIOMETRIC TRAVERSES FOR UPPER MANTLE PROJECT.

WESTERN AUSTRALIA 1966

by

D.B. TIPPER

CONTENTS

ILLUSTRATIONS

SUMMARY

As part of a special project to investigate the structure and thickness of the Earth's crust in the region of the oldest part of the Western Australian Precambrian Shield, two airborne magnetic traverses were made between Perth and Merredin at a height of 8500 ft; the results are presented, but have not yet been analysed. Eight low-level traverses were also flown and on the basis of these results, the region has been divided into zones depending on magnetic intensity and anomaly linearity, but owing to the limited extent of the area covered, no particular structure can be delineated.

1968/4

1. INTRODUCTION

The Australian Upper Mantle Committee recommended as a special project that a comprehensive and co-ordinated geophysical, geochemical, and geological investigation be made of the oldest part of the Western Australian Shield. In order to synthesise all available exploratory techniques, it was decided to concentrate them in a traverse, which would ultimately yield a comprehensive geological and geophysical cross-section of this major tectonic unit and advance the knowledge of the physical and chemical evolution of the crust and upper mantle, the nature of the crust-mantle interaction, and the early history of the Earth.

The chosen traverse zone, which extends from Perth to Coolgardie and then south-east to the Great Australian Bight near Balladonia, crosses the largest exposures of the oldest known rocks in Australia. These rocks form elongated outcrops of lava/sediment sequences ('greenstones') enclosed in a vast mass of generally acidic, igneous intrusives.

In 1966 at the request of the Geological Survey of Western Australia, on behalf of the Australian Upper Mantle Committee, the aeromagnetic survey of the upper mantle traverse zone between Perth and Merredin was made by the Bureau of Mineral Resources (BMR).

Ten magnetic and radiometric traverses were flown between Perth and Merredin (Plate 1), on 16-19th August 1966. Eight traverses were flown at low level and one mile apart with two objectives: (a) to assist the structural mapping of the zone, particularly in soil-covered regions, by delineating geological strikes and by determining widths and other parameters of the highly magnetic rock units that characterise the 'greenstone' belts; and (b) to locate outcrops of radioactive granite for subsequent sampling and petrographic analysis.

In order to investigate deep geological structure, two traverses were reflown at a constant barometric altitude of 8500 feet to attenuate the short-wavelength magnetic variations that were detected at low level, and which are due to sources at or near ground level. The objective was to determine if possible the vertical extent of the 'greenstone' sequences, and the approximate depth of the Curie point isotherm.

This Record outlines the qualitative interpretation of the results.

2. GEOLOGY

The area surveyed forms part of the Archaean Yilgarn Block, a subdivision of the Western Australian Precambrian Shield. The broad regional geology of this shield has been described by Forman (1953), Wilson (1958), and Prider (1948, 1954, 1961, 1965). The general sequence of Precambrian history is as follows. Basalts and minor rhyolite flows were extruded on to an ancient basement surface. Pillow lavas indicate that there was considerable submarine vulcanism. Interbedded shales, greywackes, tuffs, agglomerates, and banded iron formations (jaspilites) show that sedimentation was active during periods of volcanic quiescence. The lavas and sediments were intruded concordantly

by gabbros, dolerites, ultrabasic rocks, and some minor porphyries. All these rocks were then folded about north-north-westerly trending axes, contemporaneous with widespread granitic intrusion, pegmatitic and aplitic intrusion, granitisation, and metamorphism of variable grade. The granitic rocks have been dated at 2700 million years (Wilson et al, 1960). A system of subordinate folding about east-north-east to north-east axes was superimposed in the major folding; this cross-folding could be broadly contemporaneous with the major folding. Intrusion of cross-trending dolerite dykes marked the end of Precambrian time.

A number of writers (e.g. Prider, 1965) have divided the granites into an Older (synkinematic) Granite and a Younger (postkinematic) Granite. Horwitz (1966) stated that there are two granite facies but that they show contradictory age relationships. He considered that the granites are both broadly contemporaneous and in detail of several ages. Many of the granites are folded.

The geology shown in Plates 2 and 3 has been taken from the most recent Geological Map of Western Australia (published by the Geological Survey of Western Australia, 1966). The survey area consists largely of granite, which encloses only two metamorphic belts: one of metasediments south-east of Northam and the other of metasediments and metavolcanics in the extreme east of the area.

3. PRELIMINARY RESULTS AND INTERPRETATION

Magnetic

The magnetic data and a preliminary interpretation of these data are presented in Plate 2. The eight low-level profiles of total magnetic intensity were reduced to a scale of 1:250,000 and related to a series of parallel straight lines which are separated by an arbitrarily chosen one-inch interval to improve data presentation. Each profile can be compared with the topographical data of Plate 1 or the geological data of Plate 2 by way of four accurately plotted fiducial points, which are shown in both Plates 1 and 2. For the reduction of the original profiles by pantography, the aircraft's ground velocity was considered to be constant between any two successive control points. Departures from this constant velocity introduce a positional error in the presentation of the data. The probable positional error of $\pm \frac{1}{4}$ mile is a function of distance from the control points.

Plate 2 also shows the two high-level profiles of total magnetic intensity again reduced to a scale of 1:250,000. The vertical scale of these profiles (gammas/inch) is four times that for the low-level profiles.

The interpretation of the magnetic data is shown in the lower half of Plate 2. This initial qualitative analysis involved the delineation of magnetic trends and the recognition of a number of zones of differing magnetic character; some of the zones are well-defined, but others appear to graduate from one region to another. For convenience of description the zones have been classified into four groups based on

the double criteria of the degree of magnetic disturbance and anomaly linearity.

Zone 1 is characterised by low intensity magnetic disturbance (less than 100 gammas) and a lack of anomaly linearity, corresponding to granitic rock types.

In Zone 2 the magnetic intensity is of greater intensity (up to 500 gammas) without definite linearity. This zone probably corresponds with regions of greater magnetite content in the acid rocks.

Zone 3 has well defined linear anomalies, the trends of which are traceable over the width of the survey band. The anomalies are up to 1000 gammas. These are correlated with metasediments, gneissic and migmatic types.

Zone 4, on the eastern end of the survey traverse, is of greater intensity lineated anomalies typical of basic intrusives in the metamorphic zones.

Structure

No particular structure can be delineated from the magnetic profiles, mainly because of the limited extent of the area covered by the traverses. Quilty (1964), Young and Tipper (1966), Tipper (1967), and Shelley and Waller (1967) have described geological structures interpreted from regional aeromagnetic surveys on the Precambrian sheild of Western Australia.

High-level traverses

To date, the high-level aeromagnetic data have not been analysed to detect possible deep geological structure.

Radiometric

Local areas of high radioactivity are ascribed to slight radioactive mineral concentrations commonly occurring within granitic rock types. Some radiometric 'high' areas may also be due to salt pans.

4. REFERENCES

FORMAN, F.G. 1953 The geological structure of the Shield in southern Western Australia in relation to mineralisation. In GEOLOGY OF AUSTRALIAN ORE DEPOSITS. Aust. Inst. Min. Metall.

HORWITZ, R.C.	1966	Notes on the legend of the Geological Map of Western Australia. Ann. Rep. Dep. Min. W. Aust. 1965.
PRIDER, R.T.	1948	Igneous activity, metamorphism and ore formation in Western Australia. Jour. Roy. Soc. W. Aust. 31.
	1954	The Precambrian succession in Western Australia. Proc. Pann-Ind Ocean. Sci. Congr. Perth, Sect. C.
	1961	The 'greenstones' of south-western Australia. Jour. Roy. Soc. W. Aust. 44.
	1965	Geology and mineralisation of the Western Australian Shield. In GEOLOGY OF AUSTRALIAN ORE DEPOSITS. Aust. Inst. Min. Metall.
QUILTY, J.H.	1964	Interpretation of aeromagnetic data. M. Sc. Thesis, Melbourne University.
SHELLEY, E.P. and WALLER, D.R.	1967	Sir Samuel and Duketon airborne magnetic and radiometric survey, WA 1967. Bur. Min. Resour. Aust. Rec. 1967/136.
TIPPER, D.B.	1967	Laverton - Edjudina airborne magnetic and radiometric survey, WA 1966. Bur. Min. Resour. Aust. Rec. 1967/65
WILSON, A.F.	1958	Advances in the knowledge of the structure and petrology of the Precambrian rocks of South Western Australia. Jour. Roy. Soc. W. Aust. 41.
WILSON, A.F. COMPSTON, W. JEFFERY, P.M. and RILEY, G.H.	1960	Radioactive ages from the Precambrian rocks in Australia. Jour. Geol. Soc. Aust. 6.
YOUNG, G.A. and TIPPER, D.B.	1966	Menzies - Leonora airborne magnetic and radiometric survey, WA 1964. Bur. Min. Resour. Aust. Rec. 1966/15.

APPENDIX

OPERATIONAL DETAILS

Staff

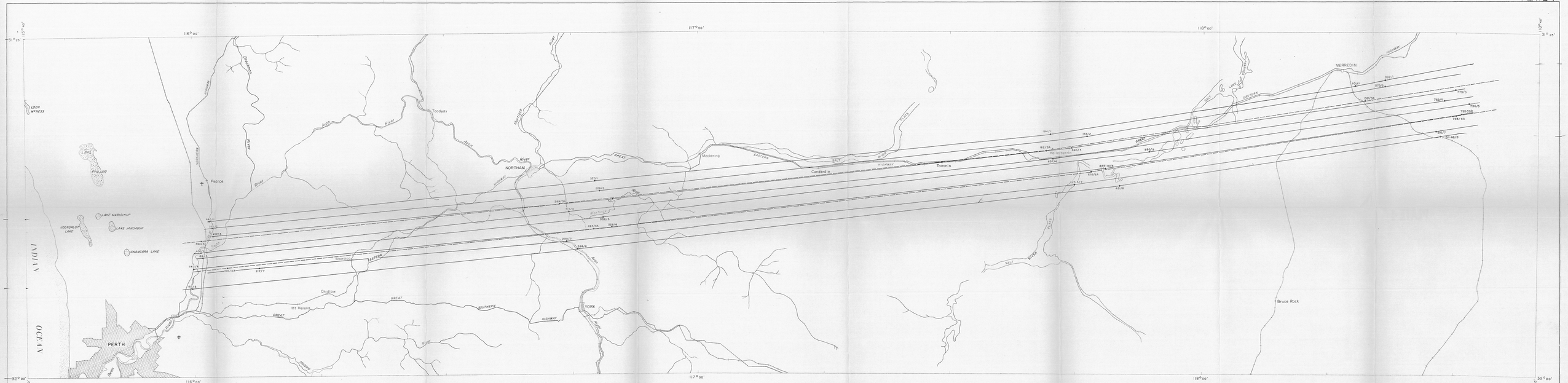
Party Leader	:	D.B. Tipper
Geophysicist	:	R.A. Gerdes
Senior Radio Technician	:	P.M. Ryan
Geophysical Assistants	:	K.A. Mort
		D. Park
		C.I. Parkinson
Drafting Assistant	:	P. Kersulis
Pilots	:	Captain G.B. Litchfield) T.A.A.
		First Officer D.A. Spiers) T.A.A.
Aircraft Maintenance Engineers	:	E. Routley) T.A.A.
		P. Derrick) T.A.A.

Equipment

Aircraft	:	D.C.3 VH-MIN
Magnetometer	:	MFS-5 saturable core fluxgate, tail boom installation and coupled to Speedomax and digital recorders
Scintillometers	:	Twin crystal MEL scintillation detector heads inboard. Single detector head outboard, suspended by a cable 290 ft below the aircraft. Outputs to De Var recorder
Camera	:	35-mm strip camera of BMR design
Radio altimeter	:	STR30B, frequency modulated type, output coupled to De Var recorder
Air position indicator	:	Track recorded by integration of aircraft heading and air-speed, on a De Var recorder.
Magnetic storm monitor	:	MFD-3 saturable core fluxgate magnetometer, ground installation, output coupled to an Esterline-Angus recorder.

Survey Specifications

Survey Altitude	:	Low level 500 feet a.g.l. High level 8500 feet a.g.l.
Magnetometer sensitivity	:	Low level, 2000 gammas f.s.d. High level, 500 gammas f.s.d.
Scintillometer time constants	:	Inboard 10 seconds Outboard 1 second Both instruments at aircraft altitude.



LOCATION DIAGRAM

INDEX TO ADJOINING SHEETS

HILL RIVER	MOORA	KENCUBBIN	JACKSON
	PERTH	YELLER-BERRIN	SOUTHERN CROSS
	PINJARRA	CORRIGIN	HYDEN

AIRBORNE TRAVERSES, MERREDIN–PERTH WA 1966

UPPER MANTLE PROJECT

4 MILES 0 4 8 12 16 20

10 KILOMETRES 0 10 20 30

TOPOGRAPHICAL LEGEND

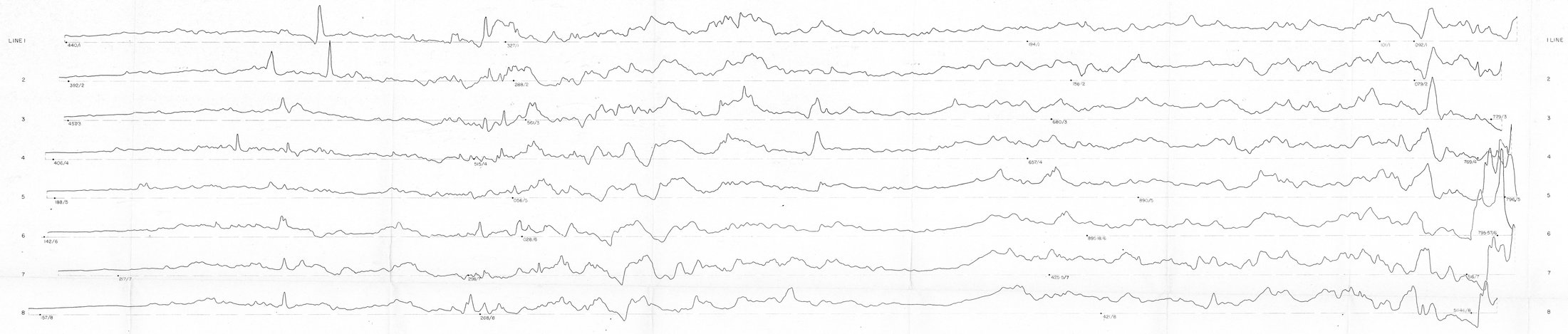
- River or creek
- Highway
- Railway with station
- Aerodrome
- Named place
- Lake
- Ocean

GEOPHYSICAL LEGEND

- 440/11 — Low level traverse with control point
- 382/3A — High level traverse with control point

TO ACCOMPANY RECORD No 1968/4

H50/B1-22

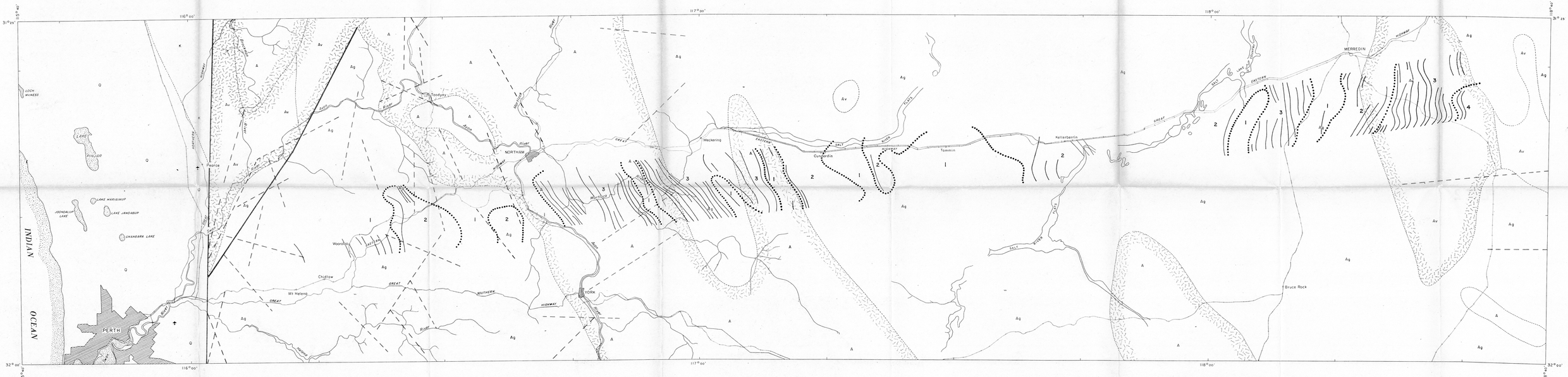


LOW LEVEL

(BASED ON H50/BI-23)

HIGH LEVEL

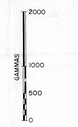
TOTAL MAGNETIC INTENSITY PROFILES



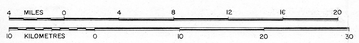
(BASED ON H50/80-13)
(BASED ON H50/81-25)

INTERPRETATION AND GEOLOGY

APPROX. VERTICAL SCALE FOR LOW LEVEL PROFILES



APPROX. VERTICAL SCALE FOR HIGH LEVEL PROFILES



GEOLOGICAL LEGEND

AFTER GEOLOGICAL MAP OF WESTERN AUSTRALIA 1966

CAINOZOIC	Quaternary	Q	Marine and continental sedimentary rocks
MESOZOIC	Cretaceous	K	Marine and continental sedimentary rocks
ARCHAEAN		Ag	Granite
		A	Sedimentary rocks
		Av	Sedimentary rocks containing basic igneous rocks
PRECAMBRIAN UNDETERMINED			Zones of high grade metamorphism and zones of migmatite and gneiss.
			Dyke
			Fault
			Geophysical boundary

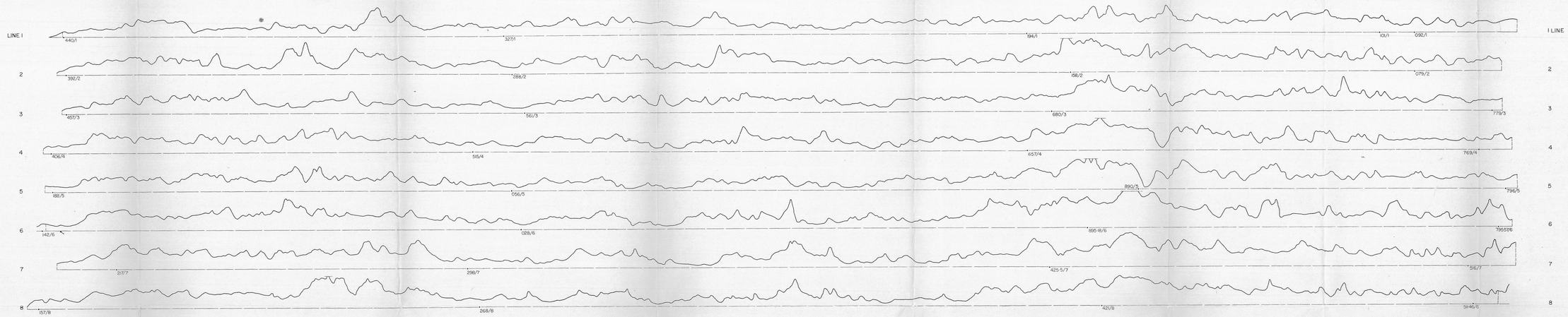
GEOPHYSICAL LEGEND

Magnetic trend

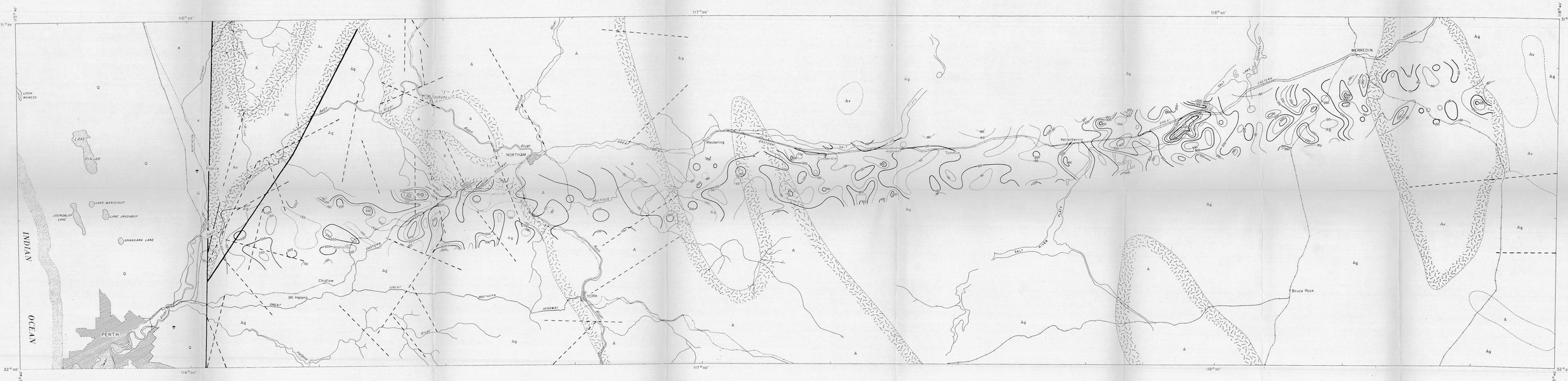
Magnetic zone

TO ACCOMPANY RECORD NR 1968/4

H50/BI-24



RADIOMETRIC PROFILES



(BASED ON H50/BO-13 & OVERLAY H50/BI-29)

RADIOMETRIC CONTOURS AND GEOLOGY

RADIOMETRIC CONTOUR INTERVAL OF 50 COUNTS PER SECOND

APPROX. VERTICAL SCALE

COUNTS PER SECOND: 1000, 500, 0

4 MILES 0 4 8 12 16 20

10 KILOMETRES 0 10 20 30

GEOLOGICAL LEGEND

AFTER GEOLOGICAL MAP OF WESTERN AUSTRALIA 1966

CAINOZOIC	Quaternary	Q	*Marine and continental sedimentary rocks*
MESOZOIC	Cretaceous	K	*Marine and continental sedimentary rocks*
ARCHAEAN		Ag	*Granite*
		A	*Sedimentary rocks*
		Av	*Sedimentary rocks containing basic igneous rocks*
PRECAMBRIAN UNDETERMINED			*Zones of high grade metamorphism and zones of migmatite and gneiss*
			Dyke
			Fault
			Geological boundary

GEOPHYSICAL LEGEND

Radiometric contours

TO ACCOMPANY RECORD Nº 1968/4

H50/BI-28