RECORD No. 1966/15

MENZIES AND LEONORA AIRBORNE MAGNETIC AND RADIOMETRIC SURVEY, WA 1964

by

G.A. YOUNG and D.B. TIPPER

CONTENTS

		Page
	SUMMARY	
1.	INTRODUCTION	1
2.	PREVIOUS GEOPHYSICAL INVESTIGATIONS	1
3.	GEOLOGY	2
4.	MAGNETIC RESULTS AND INTERPRETATION	5
5.	RADIOMETRIC RESULTS AND INTERPRETATION	9
6.	CONCLUSIONS AND RECOMMENDATIONS	10
7.	REFERENCES	10
APPENDIX 1	- Outboard radiometric anomalies	13
APPENDIX 2	- Operation details	16

ILLUSTRATIONS

			Facing Page
Figure 1.	Total magnetic intensity profiles produced by induction of thin infinite sheets in the Earth's field with inclination - 65°	(Drawing No. H51/B1-44)	8
Figure 2.	Types of radiometric anomalies	(H51/B1-42)	13
Figure 3.	Histograms of amplitude and frequency of occurrences of radiometric anomalies	(H51/B1-43)	14
Figure 4.	Relations between radiometric anomaly amplitude, frequency, and resolution	(H51/B1-43)	14
Plate 1.	Locality map	(Drawing No. H51/B1-21)	
Plate 2.	Geophysical interpretation and geology, Menzies	(H51/B1-38)	
Plate 3.	Geophysical interpretation and geology, Leonora	(H51/B1-37)	
Plate 4.	Total magnetic intensity profiles, Menzies	(H51/B1-26)	
Plate 5.	Total magnetic intensity profiles, Leonora	(H51/B1-24)	
Plate 6.	Total magnetic intensity profiles and magnetic trends, Menzies	(H51/B1-~~25~~) 57	
Plate 7.	Total magnetic intensity profiles and magnetic trends, Leonora	(H51/B1-~~23~~) 54	
Plate 8.	Radiometric profiles, Menzies	(H51/B1-34)	
Plate 9.	Radiometric profiles, Leonora	(H51/B1-33)	
Plate 10.	Radiometric results and geology, Menzies	(H51/B1-36)	
Plate 11.	Radiometric results and geology, Leonora	(H51/B1-35)	

SUMMARY

An airborne magnetic and radiometric survey of the Menzies and Leonora 1:250,000 map areas was flown by the Bureau of Mineral Resources in 1964.

Interpretation of the magnetic data is primarily qualitative and incorporates the resolution of magnetic trends and the subdivision of the survey area into zones of specified magnetic character. The geological significance of these zones has been tentatively ascribed to certain rock types.

A limited interpretation of regional geological structure has been made from a study of zonal configurations and the repetition of intrazonal magnetic anomalies, supplemented by qualitative and quantitative dip analyses.

Seven major east-west dykes have been defined, which generally appear to have widths of 1000 feet, near-vertical dips, and depths of burial within 100 feet of the surface. Two dykes have reversed magnetisation, the remainder appear normally polarised.

The convergence of magnetic and interpreted geological features at latitude 29°33'S, longitude 120°11'E, defines a locality that warrants ground investigation.

A contour presentation of radiometric data reveals a general correlation between variations in gamma radiation and both the known geology and that interpreted from magnetic data. Sixty four radiometric anomalies of restricted source have been detected, of which forty seven are recommended for ground investigation.

1. INTRODUCTION

The Bureau of Mineral Resources (BMR) commenced airborne magnetic and radiometric surveys in the goldfields region of Western Australia in 1956, and by 1960 had completed the surveys of the 1:250,000 map areas of Southern Cross, Kalgoorlie, Barlee, Jackson, Kurnalpi, Widgiemooltha, Boorabbin, Norseman, and Lake Johnston. During October and November 1964 this programme was continued with the surveying, by the BMR DC-3 aircraft VH-MIN, of the Menzies and Leonora 1:250,000 map areas, which form a northerly extension of the previously surveyed region (Plate 1). This record deals with the interpretation of the magnetic and radiometric results of the 1964 survey.

The goldfields in the area included in Plate 1 are located in the Precambrian Shield area of Western Australia, which is a complex of meta-igneous and meta-sedimentary rocks with a variety of intrusive and replacement rocks.

Forman (1953) classifies the basic meta-igneous and meta-sedimentary rocks of this Precambrian Shield into three series :

1. The Older Greenstone Series
2. The Whitestone Series
3. The Younger Greenstone Series.

These series have a dominant structural trend in a north-north-west to north-west direction. A further subdivision has been made of the Older Greenstone Series into basic lavas and a suite of ultra-basic rocks (Low, 1960). Both the Older Greenstone Series and the Whitestone Series contain minor developments of banded iron formations or jaspilites.

Mineralization, of which gold has the greatest economic importance, is predominantly confined to the greenstones, though bearing an association with intrusive granite. The concept of 'favourable beds' and 'gold lines' is supported in most geological reports on the goldfields.

The objective of this survey was to provide data to assist in the future regional mapping of the area rather than to attempt to detect economic mineralisation directly.

2. PREVIOUS GEOPHYSICAL INVESTIGATIONS

There is no reference to any previous geophysical work in the Menzies or Leonora 1:250,000 map areas, but limited work is at present being carried out by Western Mining Corporation Ltd.

The use of the airborne magnetic method in the goldfields area was advocated by Miles (1953) with the object of delineating the banded iron formations, which might serve in establishing the control on geological structures and ore genesis in areas of extensive alluvium cover. It was not suggested that direct detection of economic mineralisation would be possible in this locality.

Airborne magnetic and radiometric surveys have been flown over the following 1:250,000 map areas: Kalgoorlie, Southern Cross, Barlee, and Jackson (Spence, 1958), Kurnalpi and Widgiemooltha (Carter, 1959), Boorabbin and Norseman (Forsyth, 1961), and Lake Johnston (Wells, 1962). It has been shown (Quilty, in preparation) that the banded iron (jaspilite) formations within the Archaean metamorphosed sediments and lavas are clearly delineated in the contours of total magnetic intensity and serve as marker horizons in tracing the major fold axes. The correlation of aeromagnetic data with geological mapping in the Boorabbin 1:250,000 map area (BMR, 1963) showed that the more intense anomalies are associated with ultra-basic rocks and basic lavas of the "greenstone" phase and also with meta-dolomitic rocks of the Whitestone Phase. Quilty (in preparation) is uncertain whether all these iron-rich rocks are interbedded units of the metamorphic belts; he considers that their general conformity with the typical pattern of jaspilite outcrops suggests that they are.

Suites of basic intrusives occupying fissures produced by cross-folding of the metamorphic belts have also been recognized by their distinctive magnetic properties.

A review of geophysical surveys in ghe Norseman area (Daly, 1963) indicates that the reconnaissance airborne magnetic method is not successful in providing direct information on the occurrence of orebodies. In the Mararoa area, taken as typical for orebodies not closely associated with banded iron formations, it did not appear that this type of magnetic survey could be relied upon to give definite information on the geological structure in the greenstones.

In the case of the Iron King orebody, which is associated with structure in the banded iron formation, ground magnetic surveys showed a feature correlating with the structure; however, this feature is not visible on the aeromagnetic contour map produced from the results of flight lines spaced at $\frac{1}{4}$-mile intervals across the magnetic strike.

Interpretation of the airborne radiometric data has indicated the presence of numerous anomalies that markedly exceed the average intensity of gamma radiation. Many of these anomalies are attributed to outcrops of granite. However, in the Southern Cross-Kalgoorlie region (Mulder, 1960), 84 anomalies were recommended for ground investigation following a low-level airborne radiometric survey.

3. GEOLOGY

The geology of the region about and to the south of the survey area is of ancient, strongly folded, and highly metamorphosed igneous and sedimentary rocks that have been subjected to granitic intrusion, granitisation, and invasion by dyke suites typical of a Precambrian shield area.

The metamorphic rocks are generally exposed in belts that show a regional north-north-west trend. Major folding of the meta-igneous and meta-sedimentary rocks, generally parallels this axis, the subsidiary folds being tightly packed and often isoclinal with some overturning.

A system of subordinate folding, whose axial trend is east-north-east to north-east, is superimposed on the major regional folding and has had a significant role in localising mineralisation (Ellis, 1939 & McMath, 1953).

In the Yilgarn Goldfield a suite of late basic intrusive rocks shows an east-north-east trend and bears a close relationship to the axis of cross-folding in the metamorphic belts (Quilty, in preparation).

The geological mapping of the Menzies and Leonora 1:250,000 map areas involves little more than a distinction of regions as either granitic or greenstone types.

Menzies 1:250,000 map area

The geology shown in Plate 2 is based on data compiled by Talbot (1912) and on the Tectonic Map of Australia (BMR, 1960). Little geological information other than major rock type divisions is available. Detailed or semi-detailed mapping is confined to small areas about mining townships such as Menzies (Woodward, 1906), Mulline, Riverina, and Ularring

(Feldtmann, 1915), Kookynie, Niagara, and Tampa (Jutson, 1921a). Comet Vale (Jutson, 1921b), and Mount Ida (Gibson, 1907 & Tomich, 1955), and is discussed briefly below.

In the western part of the Menzies area, Talbot (1912) makes the broad division of rock types into granitic and greenstone areas, often on a basis of vegetation or soil type because of the limited exposures of rock in situ.

The greenstones mainly occur in long comparatively narrow belts which trend north-north-west. According to Talbot (1912) these greenstones consist principally of epidiorites with some amphibolites, the latter due to metamorphosed dykes of no great extent.

High serrated ridges formed by ferruginous quartz schists are found in all the greenstone areas; in some localities the bands occur across the full width of the greenstone belts, in others only at one edge. Talbot is not sure whether these ferruginous quartz schists represent shear zones or whether they may be highly metamorphosed sediments. They are usually inclined at a very high angle and folding is very marked in the Brooking Hills.

Numerous acidic dykes, which probably emanated from the main mass of intrusive granite, have been noted by Talbot in several localities in the different greenstone areas.

The geology of the mining centres is summarised as follows:

<u>Menzies</u>. Rock types distinguished are recent alluvium and laterites, crystalline and altered rocks, which are subdivided into basic and acidic groups, and igneous rocks that occur as dykes.

<u>Mulline, Riverina, and Ularring</u>. Rocks of the district are classified as amphibolites (including epidiorites and hornblende schists), granite, acidic dykes, basic dykes, and recent superficial deposits.

<u>Kookynie, Niagara, and Tampa</u>. The rocks of the area are almost wholly, if not entirely, of igneous origin. They form a comprehensive group, varying in composition from moderately basic rocks to highly acidic ones, ultra-basic rocks being almost entirely absent. The rocks have been generally classified as basic and intermediate rocks of igneous origin, acidic rocks of igneous origin, schistose rocks of uncertain origin, and recent superficial deposits.

The geological trend of the area is generally east-north-east, faulting not being discovered to any extent.

<u>Comet Vale</u>. The rocks of the district are divided into three main groups: basic and ultra-basic rocks, the acidic rocks, and the recent superficial deposits.

As in other mining areas auriferous mineralisation is mainly confined to quartz reefs and lode formations that are frequently contained in the fine-grained epidiorites and amphibolites of the basic and ultra-basic rock group.

<u>Mount Ida</u>. In general the district is one of greenstones (clastic and igneous), basic intrusives, porphyries, jaspilites, and erosion sediments intruded by three more-or-less separate masses of granite. The interbedded rock formations are steeply inclined and strongly folded and exhibit a high degree of metamorphism, although the metamorphic grade varies.

The oldest rocks are a series of meta-sedimentary and basic flows or tuffs of high metamorphic grade. Interbedded in this series is a band of coarse-grained hornblende-feldspar rock, which is considered to be a sill (Tomich, 1955). All known auriferous mineralisation occurs in this greenstone series, which is also intruded by a suite of basic dykes with north-east to north-north-east trend.

Another series of interbedded igneous greenstones and sediments occurs with strong folding along a north-west to north-north-west axis.

Jaspilites are associated with both series of metamorphic rocks, but they are more ferruginous and less massive in the latter series.

Of the granitic masses, the central and eastern granites are concordant, foliated, or gneissic types in which the foliation is parallel to that of the enclosing greenstones, whereas the western granite appears to be discordant.

A number of olivine dolerite dykes with uniform east-west strike transgress all rock formations including the granite.

Structurally the central granite mass occupies the core of a south-pitching anticline. No large faults have been recognized in the area; orebodies have, however, been influenced in deposition by a shear pattern.

Leonora 1:250,000 map area

The geology shown in Plate 3 is based on data compiled by Talbot (1912) and Clarke (1925), little geological information other than the broad rock type divisions being known. Detailed mapping is again confined to small areas about mining townships such as Lawlers (Gibson, 1907) and Leonora (Noldart & Bock, 1960).

The geology of the western part of the Leonora area is similar to that of the region immediately to the south, which has been dealt with already (western part of the Menzies area).

The eastern part of the area consists mainly of a greenstone belt, which trends north-north-west and passes through Lawlers and Leonora and thence continues into the Edjudina 1:250,000 map area. The greenstone belt includes a wide assortment of rocks of which the most important are the various epidiorites, amphibolites, chlorite-carbonate rocks, etc., to which the terms "greenstone" or "diorite" are generally applied. The present character of these rocks results from great local and regional metamorphism. A minor but by no means insignificant feature of the greenstones is the development of more acidic rocks both intrusive and effusive varying from andesites and porphyrites to rhyolites and quartz porphyries. What are apparently metamorphosed sediments are also included in this group. (Clarke, 1925, p. 22-23).

A series of acidic rocks have intruded the greenstone areas to form the granitic areas enclosing the greenstone belts.

Dykes ranging from camptonites to basaltic dolerites have been found to intrude both granite and greenstone.

Rather siliceous ferruginous quartzites are exposed in the greenstone belt between Gwalia and Mount Newman. Shear planes and quartz veins striking more or less at right angles to the main north-north-west shearlines and veins were noted by Clarke (1925) in the Leonora-Duketown area in addition to some ferruginous quartzites, which have an east-west course.

No continuation of the north branch of the Mount Celia-Yundamindera fault (Honman, 1917; Edjudina 1:250,000 map area) is known in this area.

The geology of the mining centres is summarised as follows:

Lawlers. The rocks have been divided into two main classes, the granites and the greenstones.

Acidic dykes are found most largely developed close to the junction of the granite and greenstones and vary from coarse-grained granite through aplites and quartz-porphyries to fine-grained compact felsites and rocks having the appearance of quartzites.

Basic dykes (dolerite) intrude the granite but cannot be distinguished in the greenstones.

Leonora. Rock types in an area of 400 square miles centred on Leonora are classified into Quaternary alluvium, surface cements, and laterites; ?Tertiary iron cappings; and Precambrian intrusives and meta-sedimentary and igneous rocks of the Margaret "System". The Precambrian intrusives include granitic rocks and quartz reefs. The Margaret "System" includes jaspilites, quartz-kyanite schists, sericitic schists, basic lavas, and epidiorites. Noldart and Bock (1960, p. 81) made the following comments regarding the structural and economic geology of this district:

"Major faulting was not observed........although small scale faulting is present....... The area forms protion of the western flank of a large synclinorium extending in a general north-north-west direction from Kookynie (Menzies 1:250,000 area) through Leonora to beyond Mt. Clifford........ Variations in the trends of the jaspilitic horizons suggest strong west-north-westerly trending anticlinal cross-folding through the point of maximum flexure of the main range. A similar, and probably stronger crossfold, is postulated following approximately along the drainage channel occupied by Lake Raeside........

Easterly of the main range is a system of sub-parallel anticlines and synclines trending in the same general direction as the range....... Repetition of the jaspilite beds by isoclinal folding has probably taken place but no evidence is available........"

4. MAGNETIC RESULTS AND INTERPRETATION

Magnetic profiles reduced to an east-west scale of 1:250,000 are shown for all flight lines in the Menzies and Leonora areas in Plates 4 and 5, respectively. A north-south scale of 1:62,500 has been used to improve data presentation. The magnetic profiles are accurately positioned near longitudes 120°22½'E and 121°07½'E. The maximum probable error, at longitudes 120°00'E, 120°45'E, and 121°30'E is ± ½ mile east-west.

Every fourth magnetic profile, together with magnetic trends, are shown for the Menzies and Leonora 1:250,000 map areas in Plates 6 and 7 respectively. In order to illustrate the magnetic trends that strike east-west, Plates 7 and 8 also show the magnetic profiles obtained from the tie-line systems.

Owing to the sparsity of geological information available in the Leonora and Menzies 1:250,000 map areas, a basically qualitative interpretation of the magnetic data has been applied. Magnetic trends have been resolved and the survey area has been zoned by consideration of magnetic character (Plates 2 and 3). Well defined anomalies have been analysed quantitatively assuming the magnetisation is wholly induced, and a qualitative assessment of structural dip has been made. Listed below are the zones with a brief description and their magnetic character.

Zone	Magnetic character
1	Random magnetic disturbance mainly less than 50 gammas
2	Random magnetic disturbance mainly in range 50-150 gammas
3	Random magnetic disturbance mainly in range 150-250 gammas
4	Random magnetic disturbance mainly greater than 250 gammas
5	Magnetic lineations with amplitudes mainly less than 150 gammas
6	Magnetic lineations with amplitudes mainly in range 150-250 gammas
7	Magnetic lineations with amplitudes mainly in range 250-500 gammas
8	Magnetic lineations with amplitudes mainly greater than 500 gammas

Geological significance of zones

Zones 1 and 2 are interpreted as either relatively homogeneous acidic igneous rocks or non-magnetic sedimentary sequences. This interpretation is based upon the magnetic profiles being generally smooth, the lack of continuity of magnetic feature between adjacent flight lines, and the generally lower magnetic intensity as compared with neighbouring zones.

Zone 1 regions are irregularly shaped; nevertheless, either individually or in groups they show some evidence of elongation trending north-north-west to north-west. If these regions are the magnetic expression of igneous rocks, this elongation may be interpreted as evidence for fold axes trending north-north-west.

Zone 2 regions cover much of the area and are extremely irregular in shape. It is probable that a number of rock types are represented, possibly including slightly more basic variations of the rocks of Zone 1.

Zone 3 regions are restricted to the western parts of the Leonora and Menzies 1:250,000 map areas. This zone is interpreted as the magnetic expression of heterogeneous igneous bodies that are of greater basicity than rocks included in Zones 1 and 2.

Zone 4 includes magnetic anomalies characterised by high amplitudes and random shape. Such anomalies are typical of major basic intrusions.

Zones 5 and 6 are transitional between Zones 1 and 2 and Zones 7 and 8. The linearity and moderately low amplitudes of the anomalies evident in Zones 5 and 6 suggest stratigraphic sequences possibly comprising lavas and sediments. Regions of both zones show a somewhat elongated character. The division between Zones 5 and 6 is based on average anomaly amplitudes. It is not implied that the two zones necessarily represent two distinct geological provinces, but rather a gradation in basicity.

Zone 7 has a high degree of linearity and elongation of regions. This is interpreted as being due to a series of basic lavas and sediments.

Zone 8 is characterised by very high amplitudes and very pronounced linearity. The anomalies may be conveniently grouped into two distinct categories, those of the order of 1000 gammas and those many times greater. Estimates of susceptibilities range from 2×10^{-3} to 3×10^{-3} CGS units and from 25×10^{-3} to 40×10^{-3} CGS units for the two groups respectively. The former anomalies are interpreted as being due to serpentinite bodies and the latter due to banded iron formations. Quilty (in preparation) records susceptibility values as high as 200×10^{-3} CGS units, which is comparable to the value obtained for the magnetic anomaly evident in the extreme south west of the Menzies area.

Analysis of magnetic trend lines oriented approximately north-south

The resolution of trend lines bears in general a direct relation to anomaly amplitude. The isolated trend lines within Zones 1 and 2 are relatively short and are possibly caused by either dykes or granitisation of pre-existing magnetic bodies. Trend lines become pronounced in Zones 5 and 6. The continuous strong lineations are almost wholly confined to the intense anomalies of Zones 7 and 8 in the Menzies area and the moderately intense anomalies of Zone 6 in the Leonora area.

Within Zone 2 and the transitional Zones 5 and 6 it is not uncommon for a trend line to pass from one zone to another. This illustrates the lack of well defined interzonal contacts and the limited difference of geological significance between these zones. Conversely, trends within Zones 7 and 8 remain, with very few exceptions, confined to their respective zones, suggesting distinct lithologies.

Menzies 1:250,000 map area. The greatest concentrations of trend lines occur in the western half of the area and are directed north-north-west to north-west. This general direction, paralleled by most other trends, is indicative of the regional strike for the entire area. Whilst individual trend lines follow the general pattern, there are local variations, most, but not all of which are located near the western boundary of the area, where positional accuracy is at a minimum.

Leonora 1:250,000 map area. Trend lines are mostly concentrated in the northern and eastern parts of the area, with a dominant trend direction north-north-west indicative of the regional strike. An exception to this is the group of trend lines directed north-north-east in the north-west of the area. This major local variation possibly results from outcrops controlled by the intersection of major fold axes. Immediately to the south, the east-west trend lines probably result from dykes.

Sharp flexures in trend lines are again probably related to positional inaccuracies of the magnetic data.

Analysis of magnetic trend lines oriented approximately east-west

The tie-line profiles shown in Plates 6 and 7 reveal the presence of seven major dykes of similar character to those reported by Quilty (in preparation). Quantitative analysis of three major dykes in the Menzies area show them to be identical in form, having widths of approximately 1000 feet and depths of burial 50 to 100 feet below ground level. The pronounced magnetic 'lows' associated with Dykes A and B (Plate 2) have been interpreted as the effect of remanent magnetisation inclined to the south and downwards at an angle of 60° to the horizontal, whereas the anomaly associated with Dyke C has been produced primarily by induced magnetisation. From this interpretation, the three dykes are calculated to dip southerly at 80°. Calculated values of apparent intensities of magnetisation for the dykes are as follows -

Dyke A	0.017×10^{-3} CGS units
Dyke B	0.004×10^{-3} CGS units
Dyke C	0.012×10^{-3} CGS units

Inspection of the magnetic anomalies associated with the remaining four dykes indicates that these dykes are in general similar to Dyke C.

Analysis of dips

There is no direct evidence that remanent magnetisation is associated with meridional-trending magnetic anomalies; accordingly, interpretation is based on the assumption that sources are magnetised by induction only. Most of these anomalies are characterised by pronounced north-south elongation and a high degree of east-west symmetry. The magnetic anomalies are therefore interpreted as being produced by two-dimensional thin sheet structures with high dip angle. Calculations of dip using Moo's method (Moo, 1965) show that with few exceptions typical anomalies yield angles ranging from 70°W through vertical to 70°E. This result is comparable with that obtained by Quilty (in preparation). Figure 1 illustrates the form of magnetic anomalies produced by induction of these infinite sheets, which strike north or N22°W and have dips 70°E, 90°, or 70°W. These anomaly forms are based on standard curves produced by Parker Gay (1963). They are similar to many of the anomalies shown in Plates 4 and 5.

The absence of magnetic 'lows' flanking positive anomalies is indicative of sources with large vertical extent.

A comprehensive calculation of dip angles has not been made owing to the uncertainty that exists regarding the basic assumption that remanent magnetisation is negligible. When regional geological mapping is carried out, re-interpretation of aeromagnetic data would be invaluable as the presence of remanent magnetisation could be ascertained by reference to the geological data.

Regional geological structure

A few major structural features have been interpreted from the magnetic data by a combined study of zonal configuration, magnetic anomaly repetition, and major displacements of magnetic trend lines. This is a development of the approach advocated by Ellis (1939) and adopted by Quilty (in preparation), which involved the study of magnetic patterns produced by arcuate remnants of banded iron formations. Interpreted fold axes are shown in Plates 2 and 3 together with the locations of major dykes.

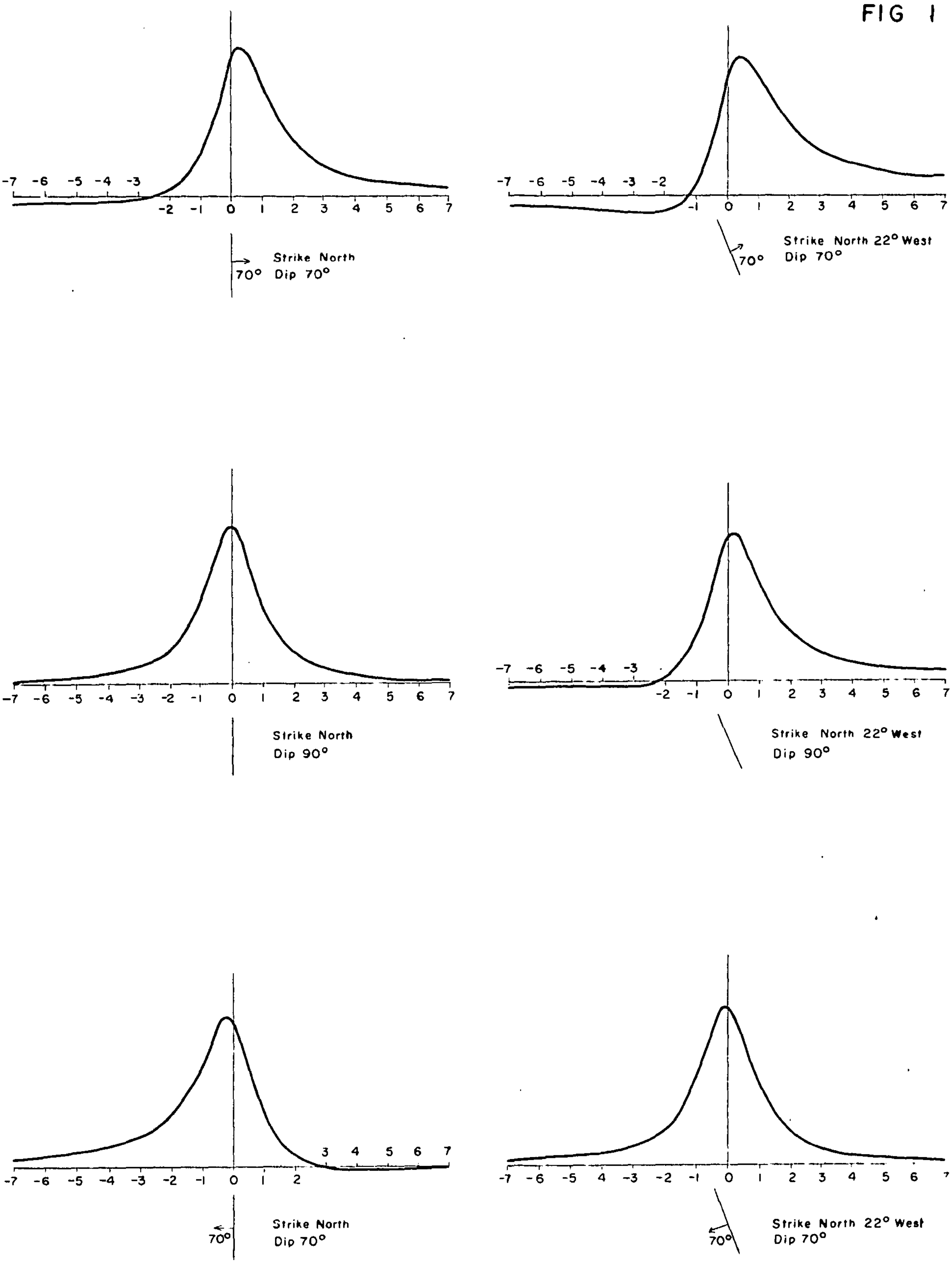
Menzies 1:250,000 map area. The limited geological control at present available in the northern part of the Kalgoorlie 1:250,000 map area indicates that major anticlinal axes are commonly defined by outcropping granite, and minor synclinal axes by basic rocks of the Greenstone Series (Kreiwaldt, pers. comm.).

The major fold axis striking north-north-west and lying in the central part of the Menzies 1:250,000 map area is interpreted as anticlinal. Evidence for this is the large region of Zone 1 flanked on both sides by areas of Zone 6 through Zone 7 to Zone 8. The convergence of magnetic trend lines near Lake Ballard indicates a northerly pitch to this anticline. Two possible major anticlines parallel to this central anticline are also shown in Plate 2.

A number of probable and possibly associated minor synclines, which are probably isoclinal in form, have been interpreted throughout the area. In the centre of the area, synclinal axes lie on either side of the anticlinal axis (striking north-north-west) and converge near Lake Ballard. This suggests a possible cross-fold axis, which is interpreted as being synclinal and coincident with the major Dyke B. In the north-east quadrant of the area, a coupling of the postulated cross-fold axis with the three synclinal axes might explain the symmetry in the zonal configurations.

Leonora 1:250,000 map area. The south-western part of this area shows a continuation of the relatively simple zonal configuration apparent in the Menzies area. The high degree of zonal complexity in the remainder of the area will, however, require extensive geological control to reveal its significance.

FIG 1



Horizontal distance is expressed in units of depth Z

TOTAL INTENSITY MAGNETIC PROFILES PRODUCED BY INDUCTION OF THIN INFINITE SHEETS IN THE EARTH'S FIELD WITH INCLINATION − 65°

H51/B1−44

A few short fold axes have been resolved as shown in Plate 3. The possibility of additional folding is recognized from the magnetic data; however, the limited degree of certainty does not warrant the display of these axes.

There is no magnetic or geological evidence to suggest the cause for the trend line convergence in the north of the area, although it almost certainly results from intersection of major fold axes.

The two major dykes do not appear to have had any recognizable control on the geological structure.

5. RADIOMETRIC RESULTS AND INTERPRETATION

Radiometric data were recorded on two scintillometers. The inboard scintillometer recorded the general level of radioactivity over the area to aid geological mapping. The purpose of the outboard scintillometer was to detect localised sources of radioactivity.

Inboard scintillometer

Profiles of radioactive intensity recorded by the inboard scintillometer have been reduced to an east-west scale of 1:250,000 and are shown for the Leonora and Menzies areas in Plates 8 and 9. A north-south scale of 1:62,500 has been used to improve data presentation. Errors in the position of the profile data are the same as those already stated for the presentation of magnetic data. Contour presentations of this radiometric data for the Leonora and Menzies areas are shown in Plates 10 and 11 together with the known geology. Some smoothing of the contours has been carried out in an attempt to minimise contour distortions produced by a combination of errors, which include the variation in aircraft-to-terrain clearance, parallax error due to delay in instrument response resulting from the ten-second time constant, curvilinear record, temperature-affected instrumental drift, and variation in instrument sensitivity.

Plates 10 and 11 show that generally low gamma radiation is associated with areas mapped as greenstones. Areas of significant anomalous amplitude have a well defined association either with the mapped rock outcrops, which commonly occur in Zones 1, 2, and 3 and are interpreted as granitic rocks, or with salt lake deposits. The anomalous areas associated with salt lake deposits are more interesting, although the source of the gamma radiation might be explained by the isotope K40. A signigicant correlation was observed between anomalous gamma radiation and the colour of the small salt lakes and clay pans to the immediate north of 19 Mile Rocks (Plate 10). Anomalous gamma radiation was seen to be greatest over the evaporites coloured brown, and least over those coloured white. Detailed photographic coverage has been made for some of these anomalies to assist ground surveying.

Outboard scintillometer

Anomalies from restricted sources detected by the outboard scintillometer in the Leonora and Menzies areas are listed in Tables 1 and 2 (Appendix 1) and are shown in Plates 10 and 11 respectively. The criteria used in selecting these anomalies are discussed in Appendix 1. The anomalies are classified in four categories, A, B, C, and D, which are illustrated in Figure 2 (facing page 13).

It is not possible to determine the significance of these anomalies in either the Leonora or Menzies 1:250,000 map areas owing to the lack of detailed geological information. To make such a determination it would be necessary to carry out a geological inspection and a ground radiometric survey; however, only anomalies of categories A and B warrant investigation, as categories C and D may prove very difficult to detect by ground work and their significance is marginal.

6. CONCLUSIONS AND RECOMMENDATIONS

The magnetic trend assessment and zonal interpretation of the survey area should be of considerable value to regional geological mapping. However, the significance of each zone can only be ascertained during the course of such mapping.

Dip angles calculated from meridional magnetic anomalies range from 70° to 90° and are similar to those interpreted from previous airborne surveys in this region. Remanent magnetisation has again been found to be associated withsome, but not all, of the east-west dykes.

It is advocated that re-interpretation of the magnetic data, in particular dip analysis, be made in conjunction with future regional geological mapping. This would test the validity, and possibly lead to the expansion, of the limited interpretation of geological structure.

The convergence of magnetic and interpreted geological features at latitude 29°33'S, longitude 120°11'E, warrants detailed ground investigation to determine whether mineralisation exists.

Data obtained from the inboard scintillometer have been successfully contoured using a contour interval of 50 counts per second. There is a general correlation between the contours and both the known geology and that interpreted from the magnetic data. The anomalous areas commonly associated with salt lake evaporites require ground investigation to ascertain the origin of the radioactivity.

The outboard scintillometer detected 64 restricted source anomalies, of which 47 warrant investigation to determine any possible economic significance.

7. REFERENCES

BMR 1960 Tectonic Map of Australia.

CARTER, R.M. 1959 A preliminary report of an airborne magnetic and radiometric survey of the Kurnalpi-Widgiemooltha areas, WA 1958. Bur. Min. Resour. Aust. Rec. 1959/137 (unpubl.)

CLARKE, E. de C. 1925 The field geology and broader mining features of the Leonora-Duketown District. Bull. Geol. Surv. W. Aust. 84.

DALY, J. 1963 Norseman geophysical surveys, WA 1946 and 1953. Bur. Min. Resour. Aust. Rec. 1963/62.

ELLIS, H.A. 1939 The geology of the Yilgarn Goldfield, South of the Great Eastern Railway, Bull. Geol. Surv. W. Aust. 97.

FELDTMANN, F.R. 1915 Geological observations in the Mulline, Riverina, and Ularring centres, North Coolgardie Goldfield. Bull. Geol. Surv. W. Aust. 64.

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

FORSYTH, W.A.L. 1961 Boorabbin and Norseman airborne magnetic and radiometric surveys, WA 1959. Bur. Min. Resour. Aust. Rec. 1961/55.

GIBSON, C.G. 1907 The geology and mineral resources of Lawlers, Sir Samuel, and Darlot (East Murchison Goldfield), Mount Ida (North Coolgardie Goldfield), and a portion of the Mt. Margaret Goldfield. Bull. Geol. Surv. W. Aust. 28.

HONMAN, G.B. 1917 The geology of the North Coolgardie Goldfield. The Yerilla District. Bull. Geol. Surv. W. Aust. 73.

JUTSON, J.T. 1921a The mining geology of Kookynie, Niagara, and Tampa, North Coolgardie Goldfield. Bull. Geol. Surv. W. Aust. 78.

1921b The mining geology of Comet Vale and Goongarrie, North Coolgardie Goldfield. Bull. Geol. Surv. W. Aust. 79.

LOW, C.H. 1960 Progress report on the survey of the Widgiemoolth area, Coolgardie Goldfield. Ann. Rep. Dep. Min. W. Aust. 1959.

McMATH, J.C. 1953 The geology of the country about Coolgardie, Coolgardie Goldfield, W.A. Part I - Regional geology. Bull. Geol. Surv. W. Aust. 107.

MILES, K.R. 1953 Banded iron formations in Western Australia. In GEOLOGY OF AUSTRALIAN ORE DEPOSITS. Aust. Inst. Min. Metall.

MOO, J.K.C. 1965 Analytical aeromagnetic interpretation. The inclined prism. Geophys. Prosp. 13(2), 203-224.

MULDER, J.M. 1960 Southern Cross and Kalgoorlie regions airborne radiometric survey, WA 1958. Bur. Min. Resour. Aust. Rec. 1960/120 (unpubl.).

NOLDART, A.J., BOCK, W.M. 1960 Notes on the geology of portion of the Mt. Malcolm District, Mt. Margaret Goldfield. Ann. Rep. Dep. Min. W. Aust. 1959.

PARKER GAY, S. 1963 Standard curves for interpretation of magnetic anomalies over long tabular bodies. Geophysics, 28(2), 161-200.

QUILTY, J. Interpretation of aeromagnetic data, Goldfield region, Western Australia. Bur. Min. Resour. Aust. Rec. (in preparation).

BMR 1963 Boorabbin, WA, 1:250,000 geological series, Sheet SH/51-13. Bur. Min. Resour. Aust. Explan. Notes.

SPENCE, A.G. 1958 Preliminary report on airborne magnetic and radiometric surveys in Kalgoorlie-Southern Cross region, Western Australia (1956-1957). Bur. Min. Resour. Aust. Rec. 1958/45 (unpubl.).

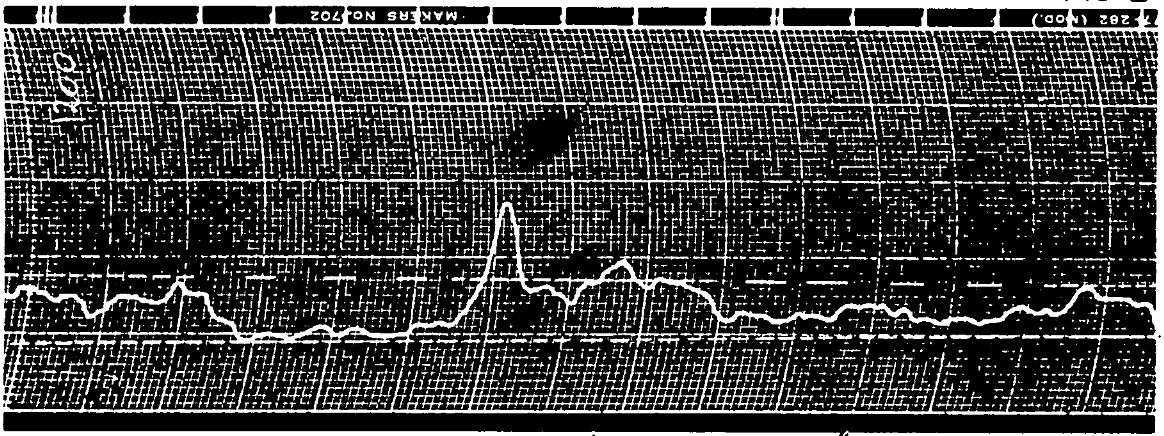
TALBOT, H.W.B. 1912 Geological investigations in the North Coolgardie and East Murchison Goldfields. Bull. Geol. Surv. W. Aust. 45.

TOMICH, S.A. 1955 Summary report on the geology of portion of the Mt. Ida district, North Coolgardie Gold field. Ann. Rep. Dep. Min. W. Aust. 1953.

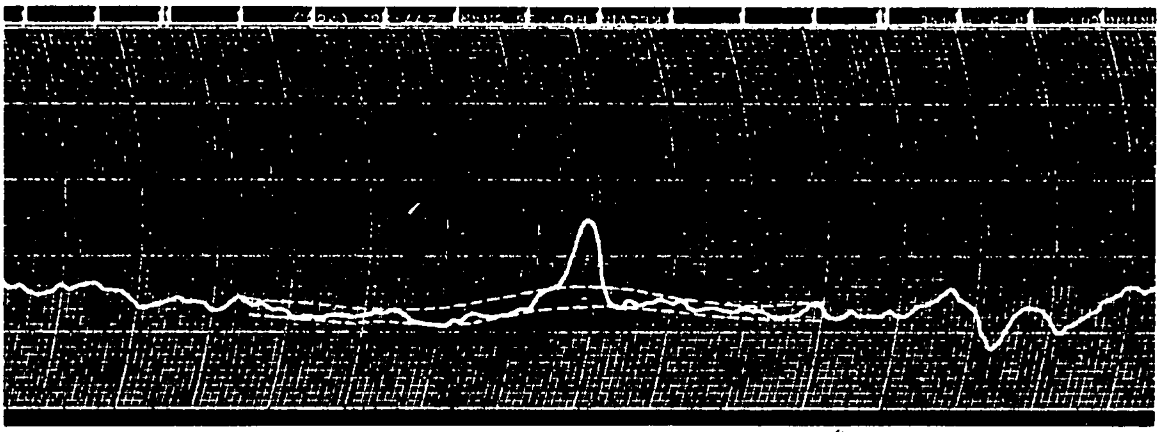
WELLS, R. 1962 Lake Johnston area airborne magnetic and radiometric survey, WA 1960. Bur. Min. Resour. Aust. Rec. 1962/100.

WOODWARD, H.P. 1906 The auriferous deposits and mines of Menzies, North Coolgardie Goldfield. Bull. Geol. Surv. W. Aust. 22

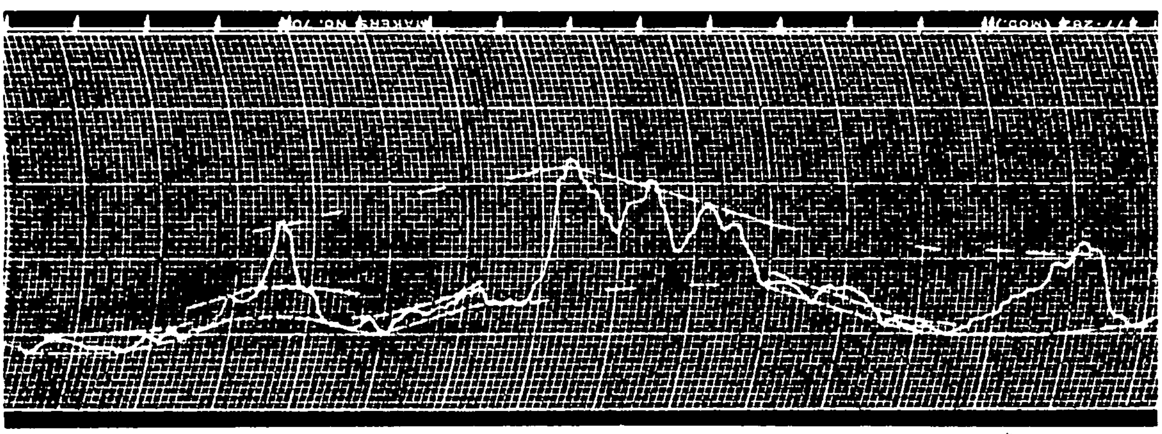
FIG 2



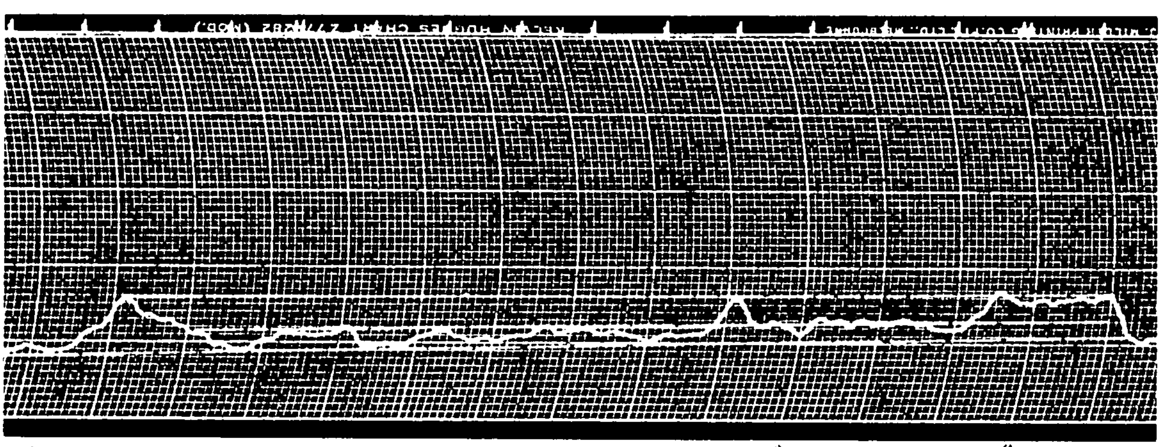
A. Anomaly significant with respect to "geological noise" envelope.



B. Anomaly significant with respect to "statistical noise" envelope.



C. Anomaly significant with respect to associated "geological noise" envelope but insignificant with respect to neighbouring "geological noise" envelope.



D. Anomaly significant with respect to associated "statistical noise" envelope but insignificant with respect to neighbouring "geological noise" envelope.

AIRBORNE SURVEY, MENZIES–LEONORA. WA 1964

TYPES OF RADIOMETRIC ANOMALIES

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics H 51/B1–42

To accompany record Nº 1966/15

APPENDIX 1

Outboard Radiometric Anomalies

Anomaly interpretation criteria

Amplitude. For an anomaly to be resolved from the normal gamma ray background noise the amplitude of the anomaly must be statistically significant. The acceptance level is set at:-

Anomaly amplitude to be greater than 3 times standard deviation of gamma ray background noise.

Gamma ray background noise. Two distinct types of gamma ray background noise are recognized; they are produced by:-

1. Statistical variation of the recorded gamma ray intensity from a homogeneous source, the standard deviation (S.D.) of the count rate being determinable from the equation:

$$S.D. = \sqrt{N/2T}$$

   where N is the count rate and T is the time constant of the counter.

2. Variation of the gamma ray intensity from a heterogeneous source, which may be produced by a geological environment involving variations in overburden above a homogeneous source.

The envelopes containing both forms of gamma ray background noise have a height of 4 times standard deviation of that noise. Typical records illustrating noise and anomalies are shown in Figure 2.

Form. Anomaly shape depends upon the configuration of the source and its location relative to the aircraft. The width of an anomaly at half peak amplitude is related to these factors and the acceptance limits set are:-

Anomaly width at half peak amplitude to be greater than 3 seconds and less than 4 seconds.

This width criterion results in the acceptance of a continuous series of sources, which is limited by sources with radii of 300 feet centred on the aircraft's line of flight and by point sources located within 300 feet of the aircraft's line of flight.

Tables 1 and 2 (pages 14 and 15) show the results of the application of the above criteria to the radiometric records.

Analysis of radiometric anomalies

Figure 3, (facing page 14) compiled from Tables 1 and 2, illustrates the distributions of the different types of radiometric anomalies with respect to their amplitudes. The decrease in the anomaly frequency with decreasing anomaly amplitude below 6 times standard deviation is probably due to a rapidly decreasing anomaly resolution that becomes zero at 3 times standard deviation. The probable relation between anomaly amplitude and resolution is shown in Figure 4. The postulated form of the true distribution of radiometric anomalies is also shown in this figure.

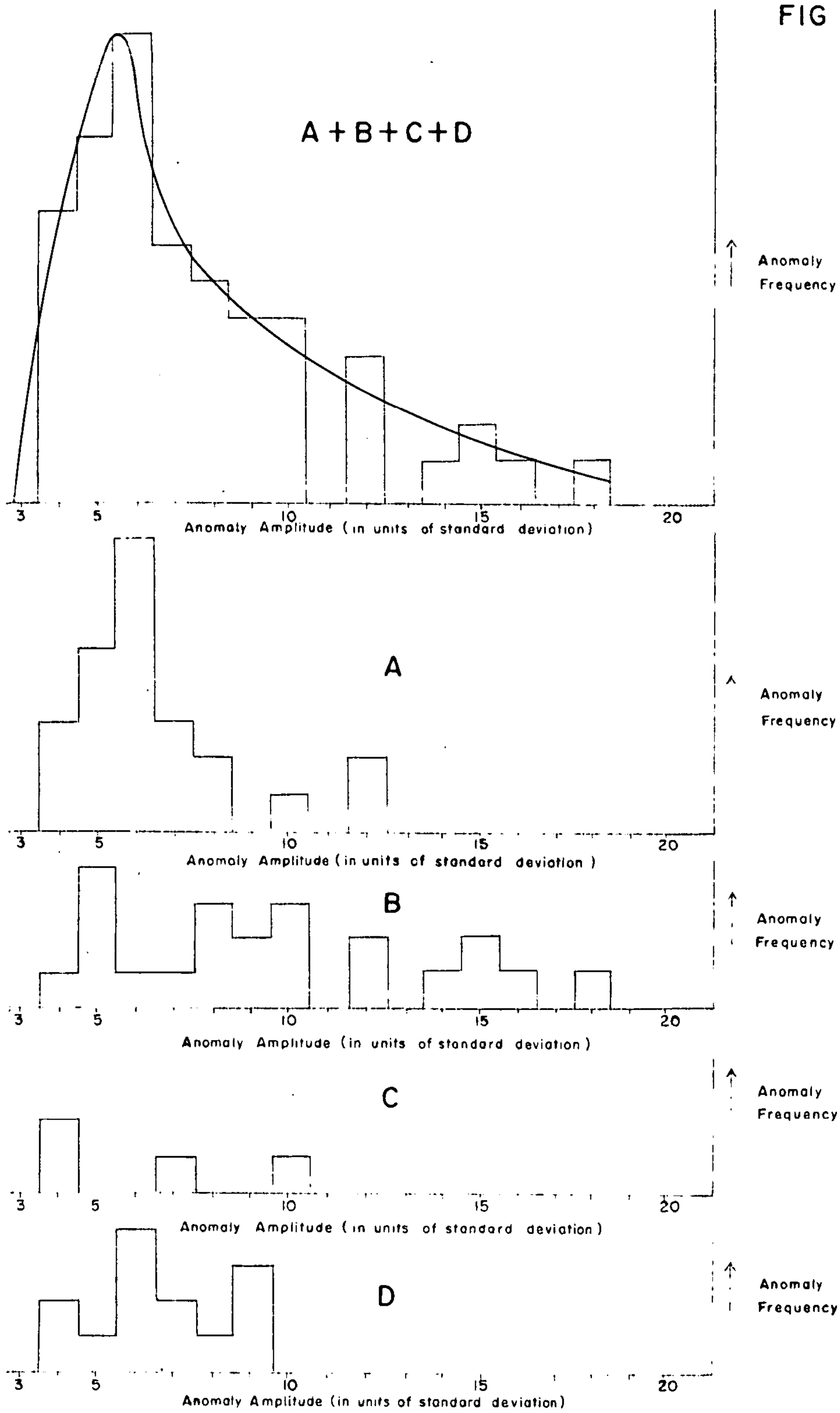
The peaking of the composite histogram of anomaly types A, B, C, and D at an amplitude 6 times standard deviation is interpreted as the interaction of curves I and II shown in Figure 4. The rapid decay in resolution evident below 7 times standard deviation is probably caused both by interference produced by statistical noise modifying the anomaly shape at half peak amplitude and by the subjective nature of the method of anomaly selection.

TABLE 1.

Outboard radiometric anomalies, Menzies 1:250,000 map area

Anomaly No.	Line No.	Fiducial No.	Half Peak width (secs)	Amplitude (x S.D.)	Anomaly Classification
1	78 W	854.8	4.0	9	D
2	78 W	849.5	4.0	9	D
3	80 W	318.7	3.5	5	A
4	84 W	795.0	3.0	8	B
5	85 N	511.1	3.5	5	B
6	86 W	290.0	3.0	8	B
7	89 W	233.1	3.0	7	A
8	91 W	599.7	3.0	8	B
9	94 E	506.6	4.0	9	B
10	94 E	528.6	3.0	7	B
11	96 E	030.2	3.0	6	A
12	97 W	805.4	3.0	4	A
13	103 E	825.5	4.0	9	B
14	103 E	974.8	4.0	10	A
15	106 W	088.3	3.0	16	B
16	108 W	753.6	3.5	6	A
17	108 W	693.9	4.0	10	B
18	110 W	167.4	3.5	12	A
19	112 W	749.3	3.0	10	C
20	114 W	139.0	4.0	12	B
21	116 E	885.0	3.5	14	B
22	116 E	922.4	4.0	6	A
23	119 W	189.8	3.5	15	B
24	120 E	885.6	3.0	4	C
25	120 E	042.4	3.5	10	B
26	121 W	820.0	3.0	7	A
27	121 W	654.1	3.0	12	B
28	122 E	430.5	4.0	7	C
29	123 W	298.8	3.5	5	A
30	123 W	297.8	4.0	6	A
31	123 W	294.3	3.5	18	B
32	128 W	184.0	4.0	7	A
33	129 E	842.0	3.5	4	A
34	133 E	944.3	4.0	6	A
35	137 E	639.2	4.0	6	A
36	137 E	686.6	4.0	8	A
37	140 W	167.1	4.0	6	A

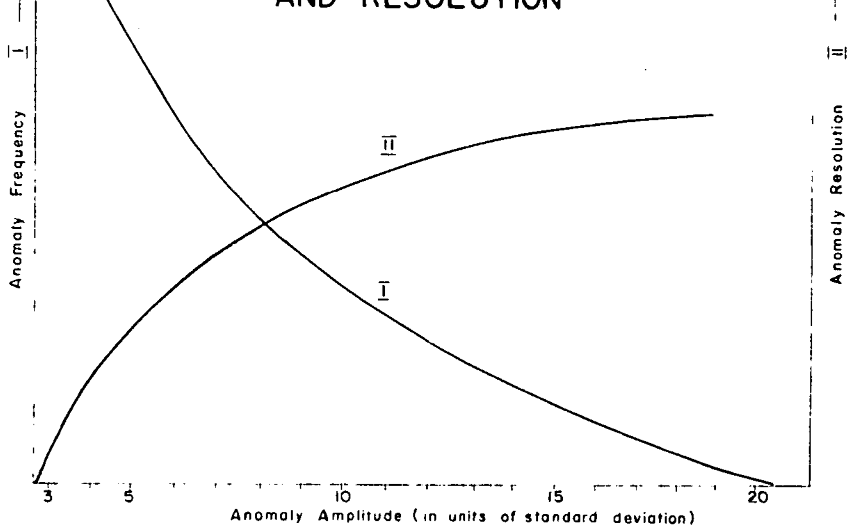
FIG 3



HISTOGRAMS OF AMPLITUDE AND FREQUENCY OF OCCURENCE OF RADIOMETRIC ANOMALIES

FIG 4

PROBABLE RELATIONSHIPS BETWEEN ANOMALY AMPLITUDE, FREQUENCY, AND RESOLUTION



H51/B1-43

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

TABLE 2

Outboard radiometric anomalies, Leonora 1:250,000 map area

Anomaly No.	Line No.	Fiducial No.	Half Peak width (secs)	Amplitude (x.S.D.)	Anomaly Classification
1	4 W	179.8	3.5	4	D
2	5 E	364.3	3.5	7	D
3	6 W	624.7	4.0	4	C
4	7 E	764.5	3.5	4	D
5	8 W	234.0	3.5	6	D
6	12 W	144.7	3.5	7	D
7	15 E	749.8	3.0	4	A
8	17 E	256.3	3.0	6	B
9	23 E	799.6	3.5	5	B
10	27 E	743.5	4.0	9	D
11	28 W	176.5	4.0	4	B
12	29 E	316.2	4.0	6	D
13	31 E	902.6	3.0	5	B
14	32 W	134.0	4.0	5	B
15	44 E	378.0	3.5	5	A
16	48 E	194.1	4.0	8	A
17	51 E	709.6	3.0	6	D
18	55 E	692.1	4.0	26	B
19	57 E	718.3	4.0	6	D
20	57 E	739.7	3.0	5	A
21	59 E	144.5	4.0	10	B
22	60 W	934.4	4.0	12	A
23	61 E	691.7	3.5	6	A
24	62 W	511.7	4.0	15	B
25	62 W	474.4	3.0	8	D
26	64 E	209.7	4.0	5	A
27	66 E	820.6	3.5	5	D

APPENDIX 2

Operational details

Staff

Party leader	G. A. Young
Geophysicist	D. B. Tipper
Senior radio technician	P. B. Turner
Draughting assistant	P. Kersulis
Geophysical assistants	K.A. Mort D. Park I. Parkinson
Pilots (TAA)	Capt. T. Newman First Officer D. Brown First Officer J. Rollston
Aircraft maintenance engineer (TAA)	B. Hall

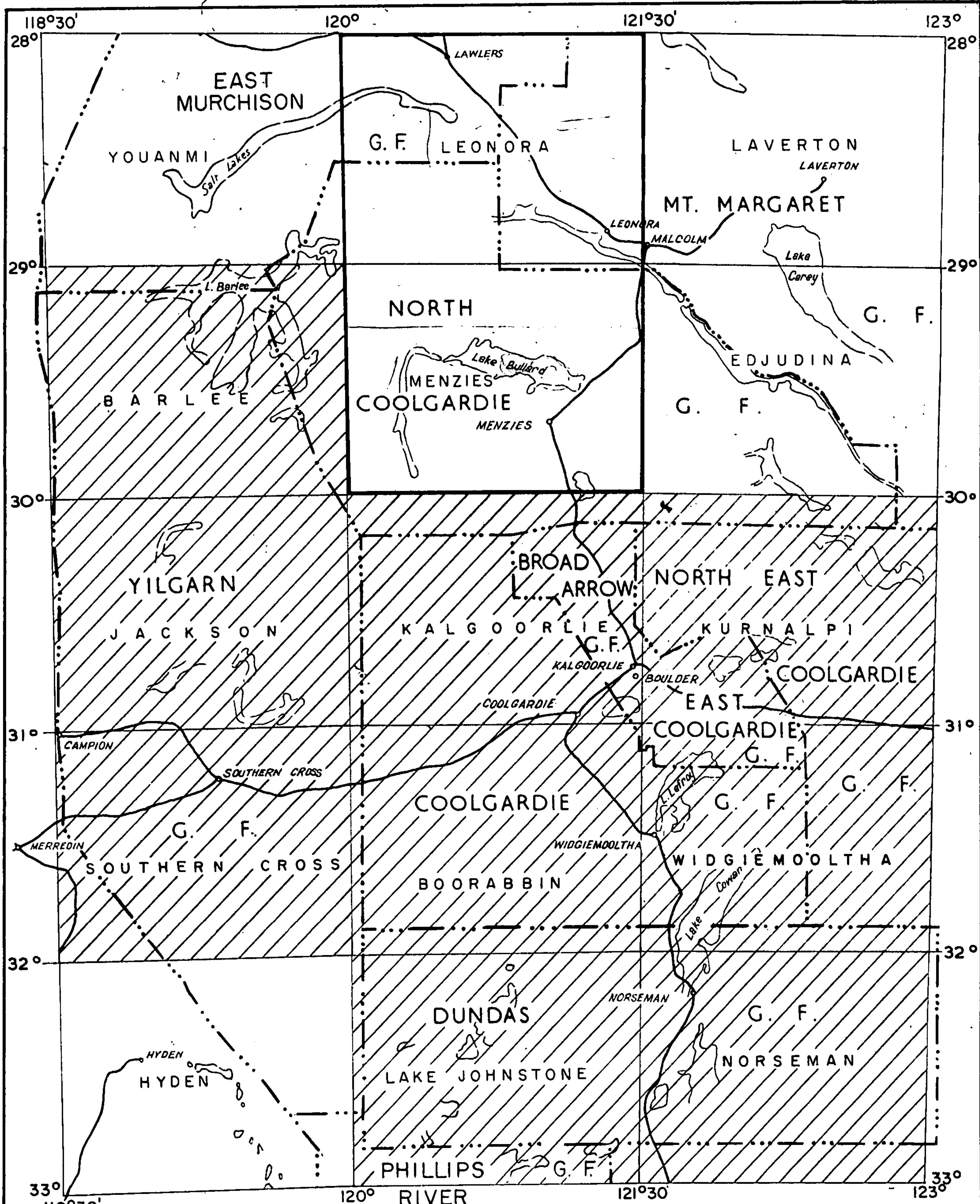
Equipment

Aircraft	DC-3 VH-MIN
Magnetometer	MFS-5 saturable core fluxgate, tail-boom installation coupled to 'Speedomax' and digital recorders.
Scintillographs	Twin crystal MEL scintillation detector heads inboard and outboard (the latter suspended from a cable 290 feet below aircraft). Outputs coupled to Kelvin Hughes recorders.
Camera	"Aeropath", 35-mm. strip
Radio altimeter	STR30B, frequency modulated type
Air position indicator	Track recorded by Esterline-Angus recorder
Magnetometer	MFD-3 saturable core fluxgate, ground installation for storm warning.

Survey specifications

Altitude	500 feet above ground level
Line spacing	1 mile
Line orientation	East/west
Tie system	Single lines spaced 15 miles apart, double lines at eastern and western boundaries of individual 1:250,000 map areas
Navigation control	Aerial photographs
Record sensitivity MFS-5	100 gammas/inch
Inboard scintillometer	100 c/s per centimetre
Outboard scintillometer	100 c/s per centimetre
Scintillometer time constants	
Inboard	10 seconds
Outboard	1 second

PLATE I



LOCALITY MAP

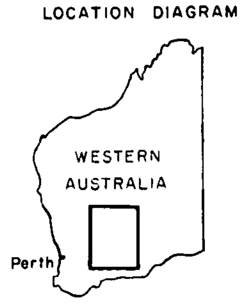
AIRBORNE MAGNETOMETER AND SCINTILLOGRAPH SURVEY 1964

MENZIES - LEONORA AREA WA

SCALE IN MILES

40 0 40 80 120

LOCATION DIAGRAM



AREA PREVIOUSLY SURVEYED

1964 SURVEY BOUNDARY

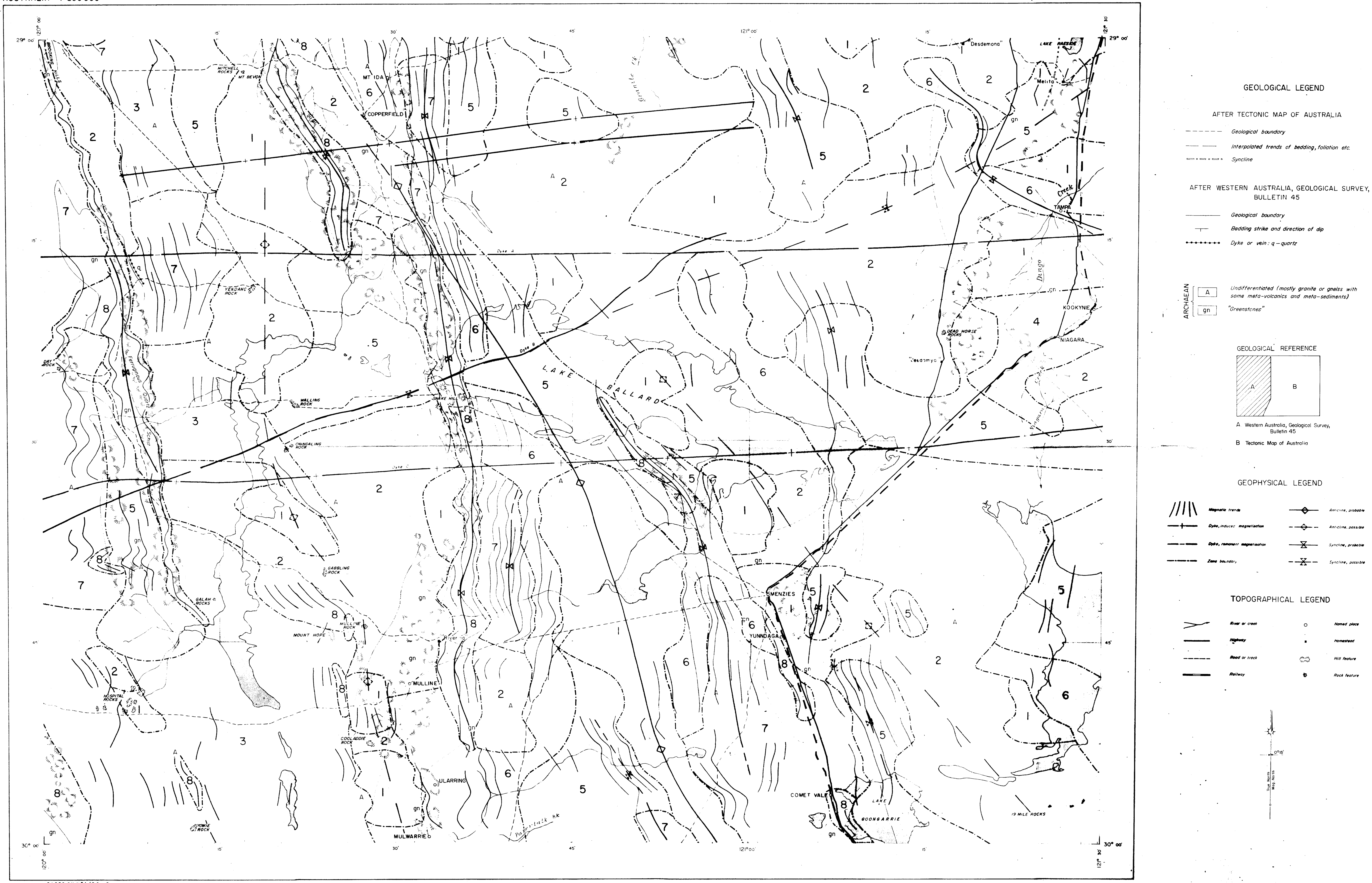
GOLDFIELDS BOUNDARIES

Geophysical Branch, Bureau of Mineral Resources Geology & Geophysics. H51/B1-21

To accompany record No 1966/15

AUSTRALIA 1:250000

MENZIES
WESTERN AUSTRALIA



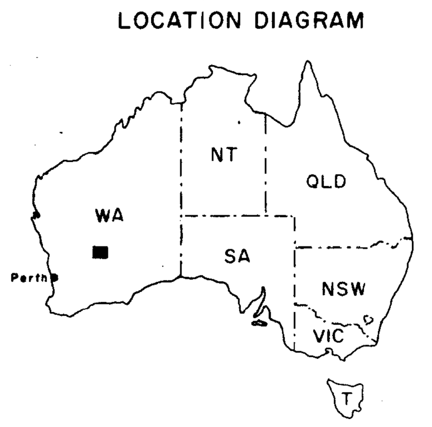
AIRBORNE SURVEY, MENZIES - LEONORA, WA 1964

GEOPHYSICAL INTERPRETATION

AND

GEOLOGY

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

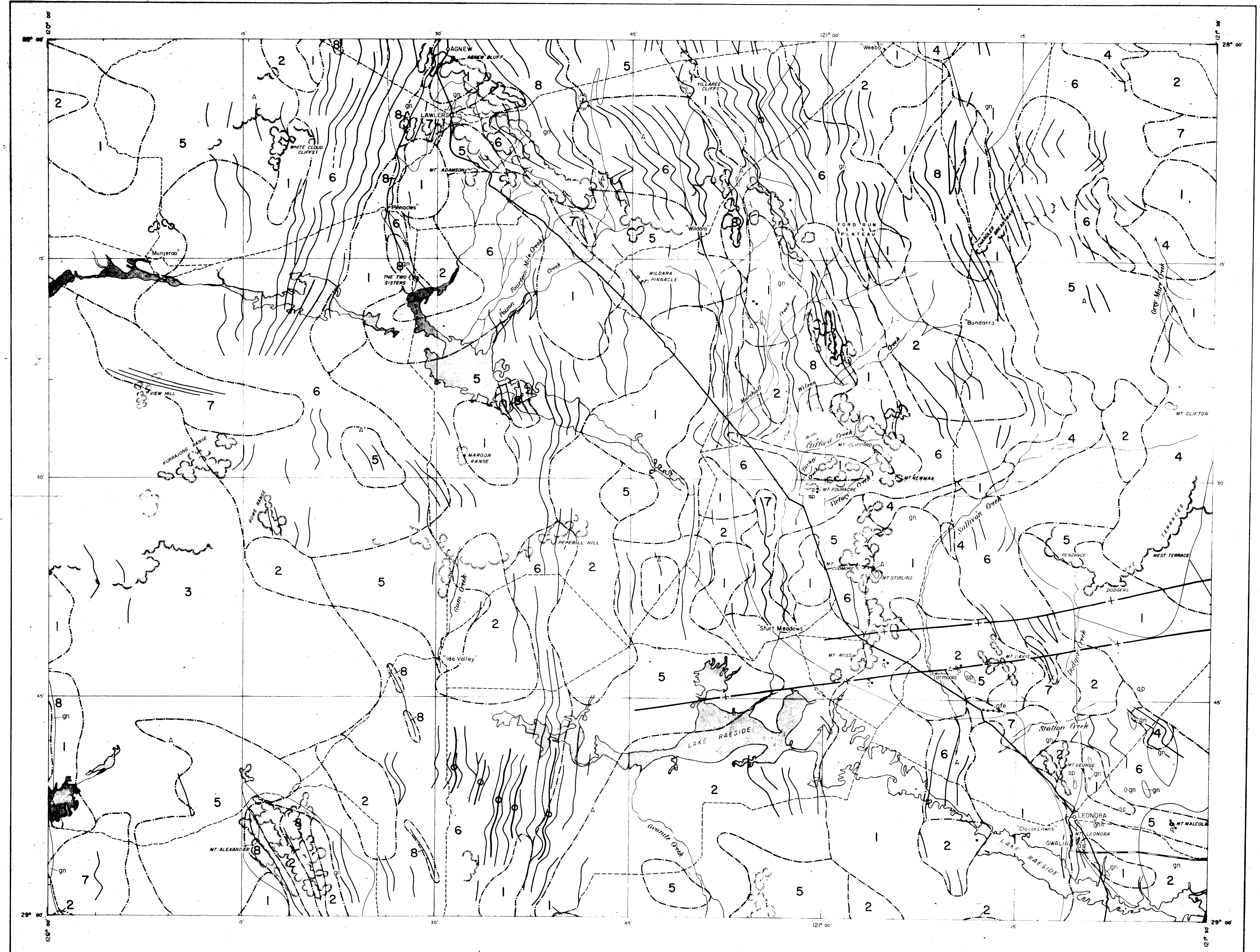
YOUANMI	LEONORA	LAVERTON
BARLEE	MENZIES	EDJUDINA
JACKSON	KALGOORLIE	KURNALPI

MILES 4 0 4 8 12 16 20 MILES

KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

AUSTRALIA 1:250,000

LEONORA
WESTERN AUSTRALIA



GEOLOGICAL LEGEND

AFTER TECTONIC MAP OF AUSTRALIA

Geological boundary

ARCHAEAN
- A — Undifferentiated (mostly granite or gneiss with some meta-volcanics and meta-sediments)
- gn — "Greenstones"

AFTER WESTERN AUSTRALIA, GEOLOGICAL SURVEY, BULLETINS 45 AND 84

- Geological boundary
- Bedding, strike and direction of dip
- Dyke or vein: quartz - q, jasper - qfe
- Quartz blow

METAMORPHOSED SEDIMENTARY ROCKS
- as — Andalusite

OLDER IGNEOUS ROCKS
- gn — "Greenstones" — Derivatives of dolerites and gabbros
- sp — Serpentine
- qp — Contemporaneous acid rocks — Foliated quartz porphyries (granite schists)

LATER ACID IGNEOUS ROCKS
- A — Granite and contemporaneous porphyry and porphyrite dykes.

GEOLOGICAL REFERENCE

A. Western Australia, Geological Survey, Bulletin 45
B. Western Australia, Geological Survey, Bulletin 84
C. Tectonic Map of Australia

GEOPHYSICAL LEGEND

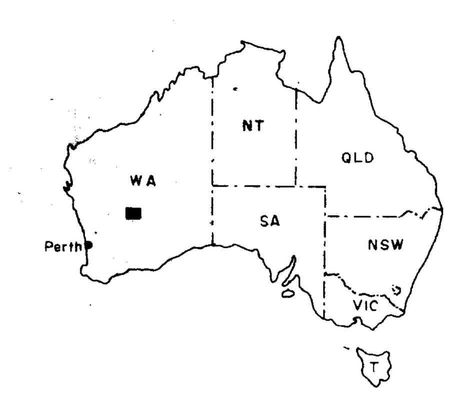
- Magnetic trends
- Zone boundary
- Dyke, induced magnetisation
- Probable fold axis

TOPOGRAPHICAL LEGEND

- River or creek
- Named place
- Highway
- Homestead
- Road or track
- Hill feature
- Railway
- Rock feature

BASED ON H51/BO-3
BASED ON H51/BI-59

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

SANDSTONE	SIR SAMUEL	DUKETON
YOUANMI	LEONORA	LAVERTON
BARLEE	MENZIES	EDJUDINA

AIRBORNE SURVEY, MENZIES - LEONORA, WA 1964

GEOPHYSICAL INTERPRETATION AND GEOLOGY

MILES 4 0 4 8 12 16 20 MILES
KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. H51/B1-37
To accompany record Nº 1968/15

MENZIES

WESTERN AUSTRALIA

AIRBORNE SURVEY, MENZIES-LEONORA, WA 1964

TOTAL MAGNETIC INTENSITY PROFILES

LOCATION DIAGRAM

INDEX TO ADJOINING SHEETS

YOUANMI	LEONORA	LAVERTON
BARLEE	MENZIES	EDJUDINA
JACKSON	KALGOORLIE	KURNALPI

EAST-WEST SCALE

MILES 5 — 0 — 5 — 10 — 15 — 20 MILES

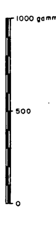
KILOMETRES 5 — 0 — 5 — 10 — 15 — 20 — 25 — 30 KILOMETRES

NORTH-SOUTH SCALE

MILES 1 — 0 — 1 — 2 — 3 — 4 — 5 MILES

KILOMETRES 1 — 0 — 1 — 2 — 3 — 4 — 5 — 6 — 7 KILOMETRES

APPROX. PROFILE SCALE



EXPLANATORY NOTES

THE SURVEY WAS MADE WITH A D.C.3 AIRCRAFT AT AN ALTITUDE OF 500 FEET ABOVE GROUND LEVEL ALONG LINES SPACED ONE MILE APART.

THE TOTAL MAGNETIC INTENSITY PROFILES HAVE BEEN CORRECTED FOR THE SOUTH COMPONENT OF A REGIONAL GRADIENT IN TOTAL INTENSITY. THIS COMPONENT AMOUNTS TO 8 GAMMAS PER MILE.

THE FLIGHT-LINES ARE IDEALISED, AND SERVE AS BASELINES TO THE PROFILES. THE MAGNETIC DATA HAVE BEEN POSITIONED WITH A PROBABLE ERROR OF ± ½ MILE.

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. H51/B1-26
To accompany record Nº 1966/15

PLATE 5

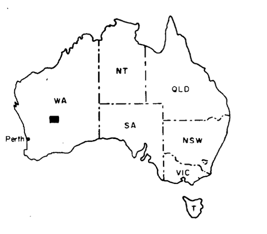
LEONORA

WESTERN AUSTRALIA

AIRBORNE SURVEY, MENZIES-LEONORA, WA 1964

TOTAL MAGNETIC INTENSITY PROFILES

LOCATION DIAGRAM

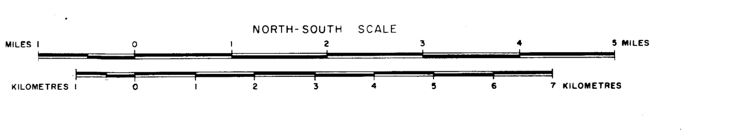


INDEX TO ADJOINING SHEETS

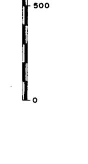
SANDSTONE	SIR SAMUEL	DUKETON
YOUANMI	LEONORA	LAVERTON
BARLEE	MENZIES	EDJUDINA

EAST-WEST SCALE

NORTH-SOUTH SCALE



APPROX. PROFILE SCALE



EXPLANATORY NOTES

THE SURVEY WAS MADE WITH A D.C.3 AIRCRAFT AT AN ALTITUDE OF 500 FEET ABOVE GROUND LEVEL ALONG LINES SPACED ONE MILE APART.

THE TOTAL MAGNETIC INTENSITY PROFILES HAVE BEEN CORRECTED FOR THE SOUTH COMPONENT OF A REGIONAL GRADIENT IN TOTAL INTENSITY. THIS COMPONENT AMOUNTS TO 8 GAMMAS PER MILE.

THE FLIGHT-LINES ARE IDEALISED, AND SERVE AS BASELINES TO THE PROFILES. THE MAGNETIC DATA HAVE BEEN POSITIONED WITH A PROBABLE ERROR OF ± 1/2 MILE.

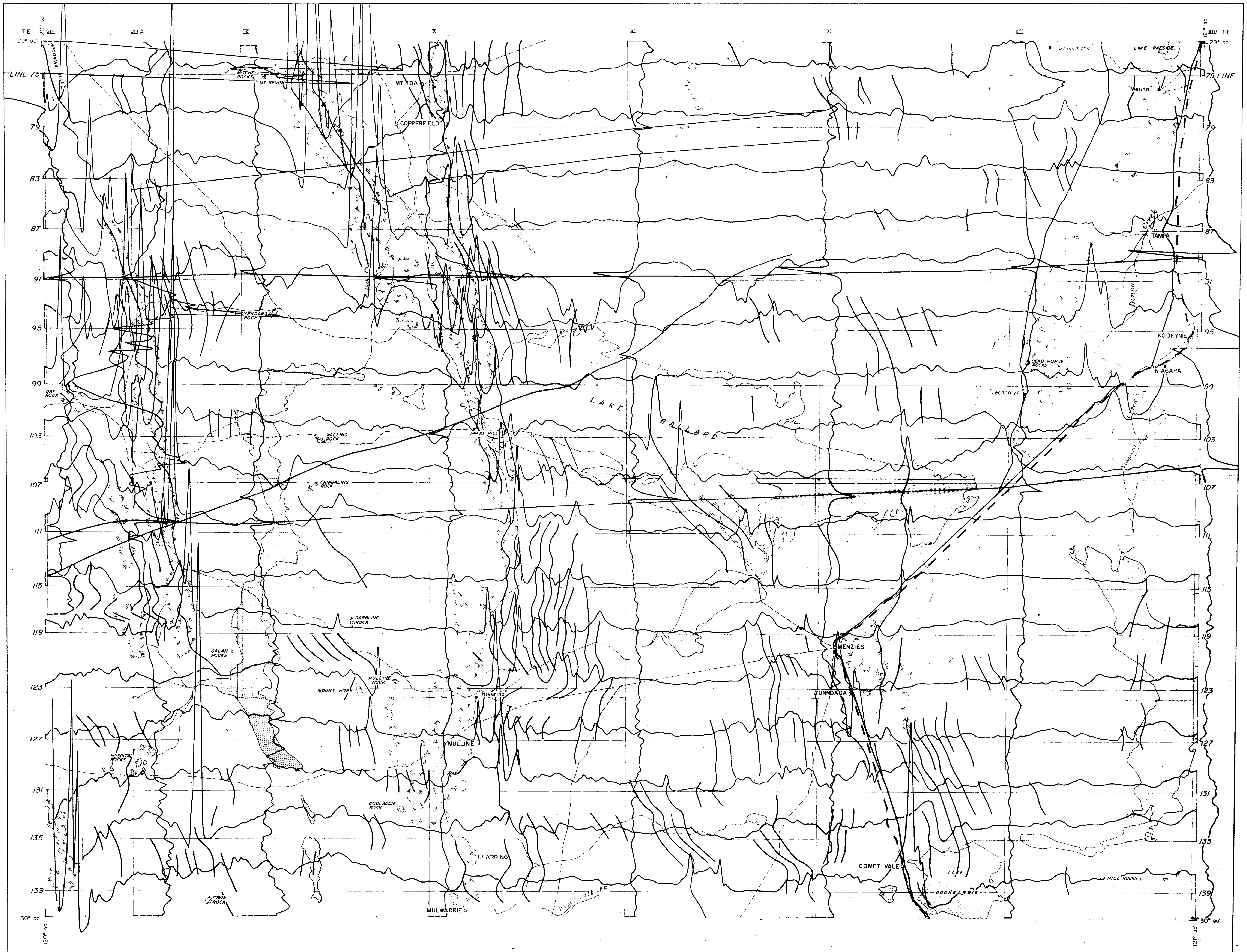
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. H51/B1-24

To accompany record Nº 1966/15

AUSTRALIA 1 250 000

MENZIES

WESTERN AUSTRALIA



BASED ON H51/B0–4
BASED ON H51/B1–25
BASED ON H51/B1–55
BASED ON H51/B1–56

GEOPHYSICAL LEGEND

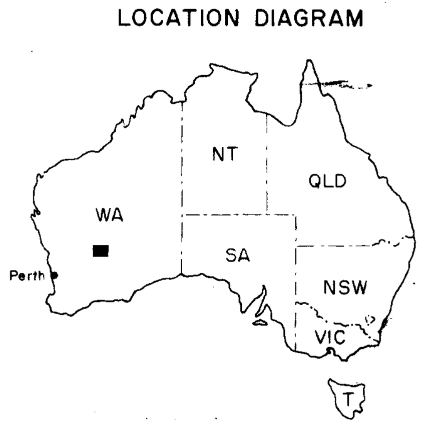
- Magnetic profile
- Flight line
- Magnetic trends

TOPOGRAPHICAL LEGEND

- River or creek
- Highway
- Road or track
- Railway
- Named place
- Homestead
- Hill feature
- Rock feature

True North / Mag North 0°15'

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

YOUANMI	LEONORA	LAVERTON
BARLEE	MENZIES	EDJUDINA
JACKSON	KALGOORLIE	KURNALPI

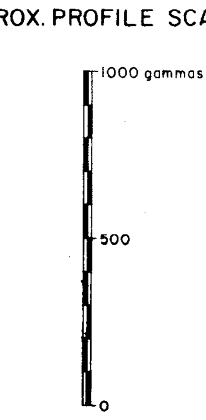
AIRBORNE SURVEY, MENZIES-LEONORA, WA 1964

TOTAL MAGNETIC INTENSITY PROFILES AND MAGNETIC TRENDS

MILES 4 0 4 8 12 16 20 MILES

KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

APPROX. PROFILE SCALE



EXPLANATORY NOTES

THE SURVEY WAS MADE WITH A DC3 AIRCRAFT AT AN ALTITUDE OF 500 FEET ABOVE GROUND LEVEL ALONG LINES SPACED ONE MILE APART.

THE TOTAL MAGNETIC INTENSITY PROFILES HAVE BEEN CORRECTED FOR THE SOUTH COMPONENT OF A REGIONAL GRADIENT IN TOTAL INTENSITY. THIS COMPONENT AMOUNTS TO 8 GAMMAS PER MILE.

PROFILES RECORDED AT INTERVALS OF FOUR MILES ARE SHOWN ON THE MAP.

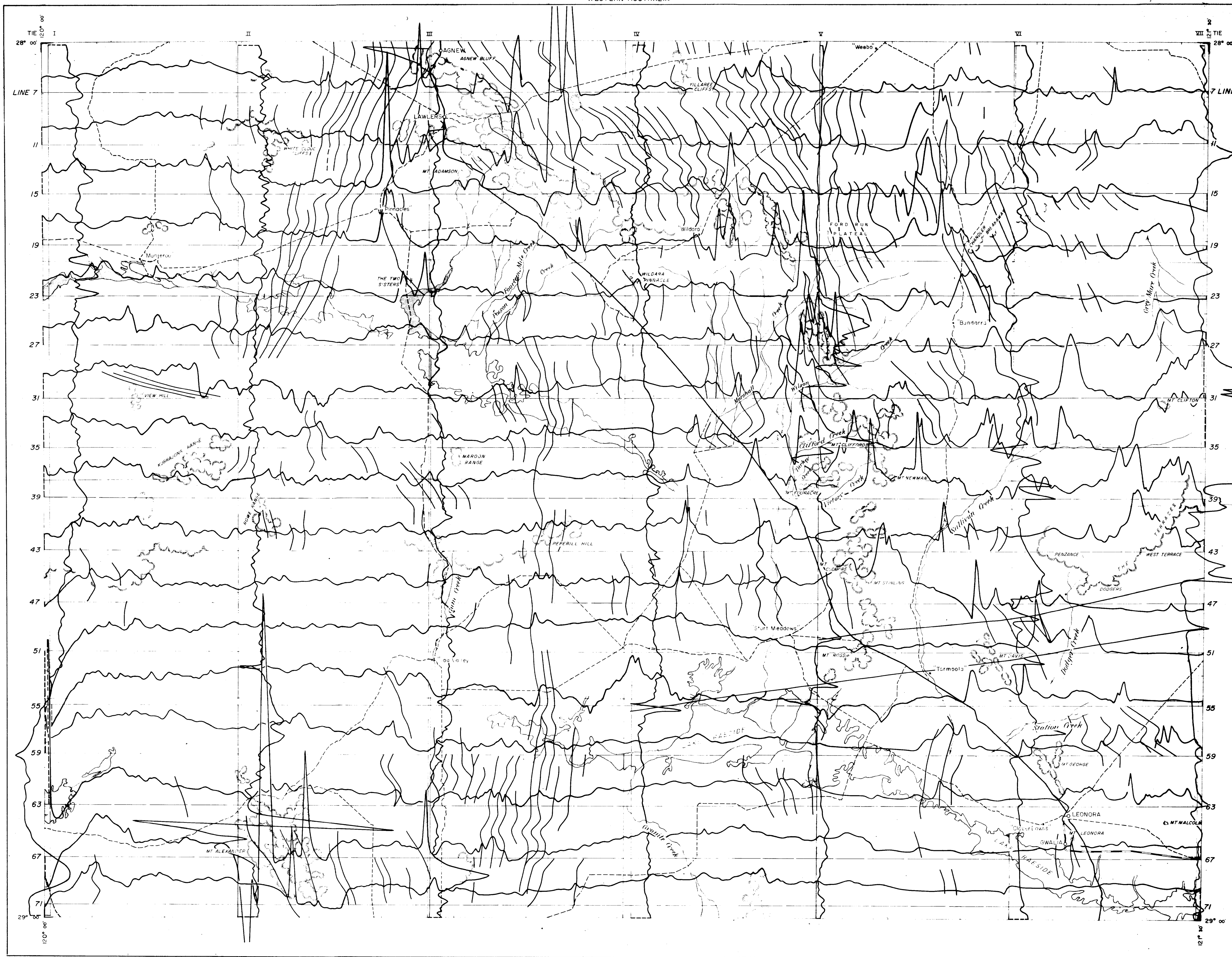
THE FLIGHT-LINES ARE IDEALISED, AND SERVE AS BASELINES TO THE PROFILES. THE MAGNETIC DATA HAVE BEEN POSITIONED WITH A PROBABLE ERROR OF ± ½ MILE.

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. H51/B1-57
To accompany record No 1966/15

AUSTRALIA 1:250000

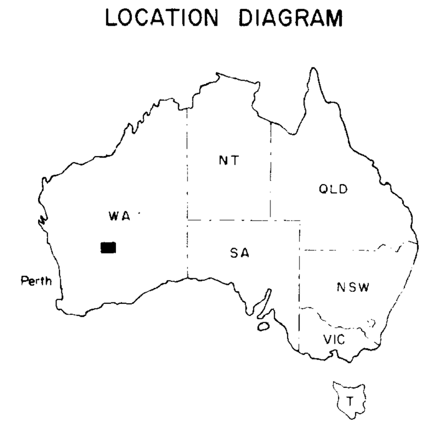
LEONORA

WESTERN AUSTRALIA



BASED ON H51/B0-2
BASED ON H51/B1-23
BASED ON H51/B1-52
BASED ON H51/B1-53

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

SANDSTONE	SIR SAMUEL	DUKETON
YOUANMI	LEONORA	LAVERTON
BARLEE	MENZIES	EDJUDINA

AIRBORNE SURVEY, MENZIES-LEONORA, WA 1964

TOTAL MAGNETIC INTENSITY PROFILES AND MAGNETIC TRENDS

MILES 4 0 4 8 12 16 20 MILES

KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

APPROX. PROFILE SCALE

1000 gammas

500

0

EXPLANATORY NOTES

THE SURVEY WAS MADE WITH A DC.3 AIRCRAFT AT AN ALTITUDE OF 500 FEET ABOVE GROUND LEVEL ALONG LINES SPACED ONE MILE APART.

THE TOTAL MAGNETIC INTENSITY PROFILES HAVE BEEN CORRECTED FOR THE SOUTH COMPONENT OF A REGIONAL GRADIENT IN TOTAL INTENSITY. THIS COMPONENT AMOUNTS TO 8 GAMMAS PER MILE.

PROFILES RECORDED AT INTERVALS OF FOUR MILES ARE SHOWN ON THE MAP.

THE FLIGHT-LINES ARE IDEALISED, AND SERVE AS BASELINES TO THE PROFILES. THE MAGNETIC DATA HAVE BEEN POSITIONED WITH A PROBABLE ERROR OF ± ½ MILE.

GEOPHYSICAL LEGEND

- Magnetic trends
- Flight line
- Magnetic profile

TOPOGRAPHICAL LEGEND

- River or creek
- Highway
- Road or track
- Railway
- Named place
- Homestead
- Hill feature

0°30'

True North
Mag North

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. H51/B1-54

To accompany record Nº 1966/15

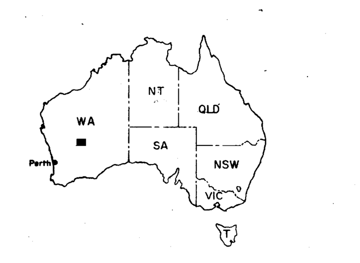
MENZIES

WESTERN AUSTRALIA

AIRBORNE SURVEY, MENZIES – LEONORA, WA 1964

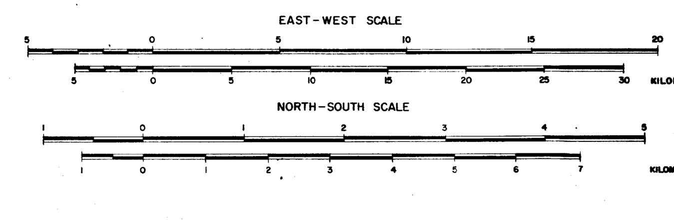
RADIOMETRIC PROFILES

LOCATION DIAGRAM

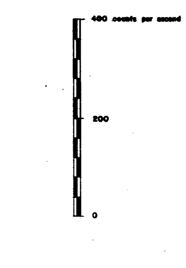


INDEX TO ADJOINING SHEETS

YOUANMI	LEONORA	LAVERTON
BARLEE	MENZIES	EDJUDINA
JACKSON	KALGOORLIE	KURNALPI



APPROX. PROFILE SCALE



EXPLANATORY NOTES

THE SURVEY WAS MADE WITH A DC.3 AIRCRAFT AT AN ALTITUDE OF 500 FEET ABOVE GROUND LEVEL, ALONG LINES SPACED ONE MILE APART.

THE RADIOMETRIC PROFILES HAVE BEEN CORRECTED FOR THE RADIOMETRIC BACKGROUND MEASURED AT 2000 FEET ABOVE GROUND LEVEL.

THE FLIGHT-LINES ARE IDEALISED, AND SERVE AS BASELINES TO THE PROFILES. THE RADIOMETRIC DATA HAS BEEN POSITIONED WITH A PROBABLE ERROR OF ± 1/2 MILE.

PROFILE INTERPOLATED

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. H51/B1-34

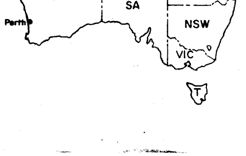
To accompany record No. 1966/15

LEONORA
WESTERN AUSTRALIA

AIRBORNE SURVEY, MENZIES – LEONORA, WA 1964

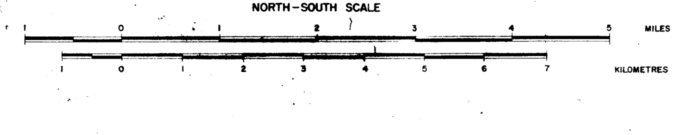
RADIOMETRIC PROFILES

LOCATION DIAGRAM

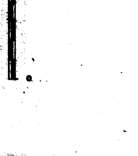


INDEX TO ADJOINING SHEETS

SANDSTONE	SIR SAMUEL	DUKETON
YOUANMI	LEONORA	LAVERTON
BARLEE	MENZIES	EDJUDINA



APPROX. PROFILE SCALE



EXPLANATORY NOTES

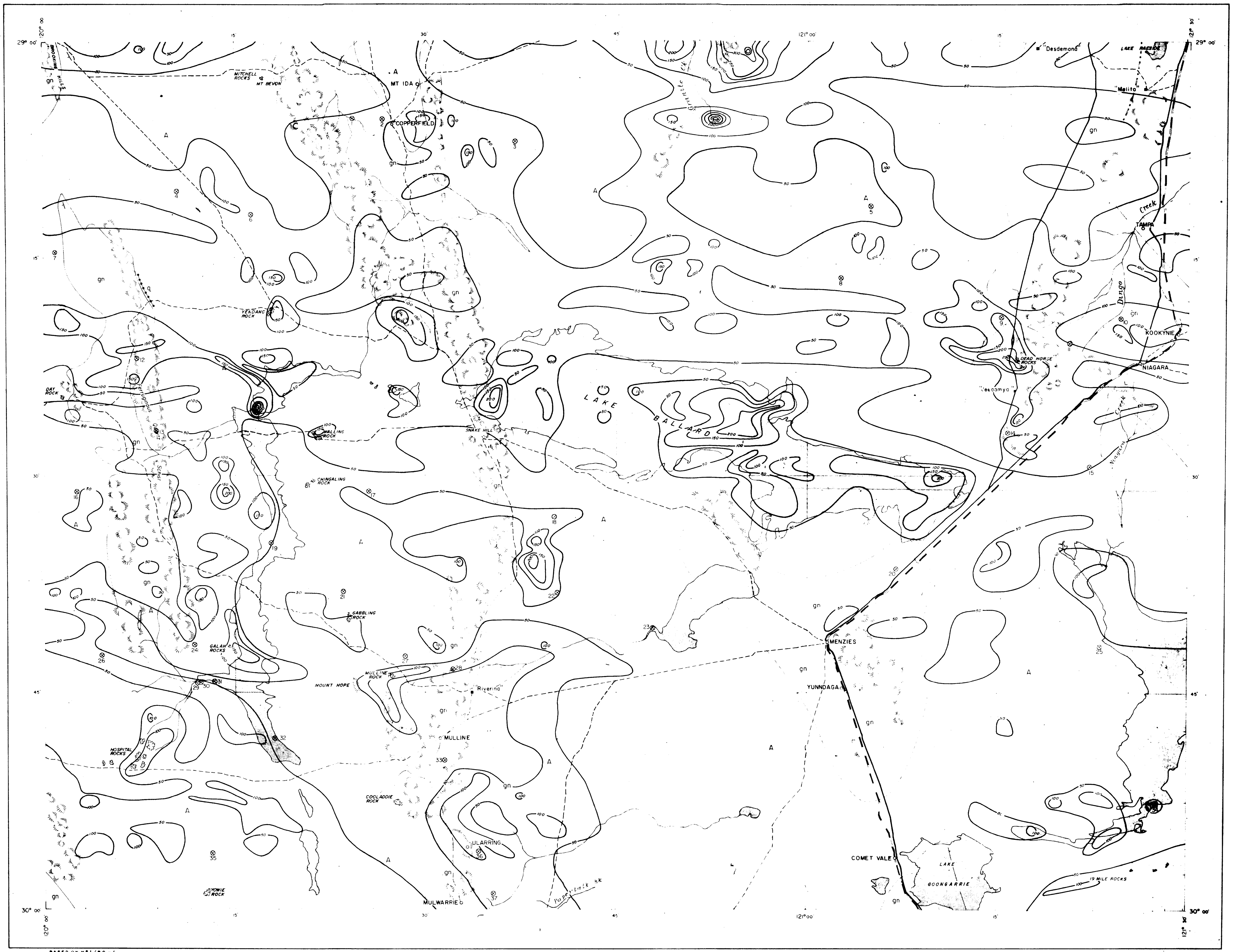
THE SURVEY WAS MADE WITH A DC.3 AIRCRAFT AT AN ALTITUDE OF [illegible] GROUND LEVEL, ALONG LINES SPACED ONE MILE APART.
THE RADIOMETRIC PROFILES HAVE BEEN CORRECTED FOR THE [illegible] MEASURED AT 2000 FEET ABOVE GROUND LEVEL.
THE FLIGHT-LINES ARE IDEALISED, AND SERVE AS BASELINES TO THE PROFILES.
THE RADIOMETRIC DATA HAS BEEN POSITIONED WITH A PROBABLE ERROR OF ± 1/2 MILE

PROFILE INTERPOLATED

Geophysical Branch, Bureau of Mineral Resources, Geology and [illegible]
To accompany record Nº 1966/15

AUSTRALIA 1:250 000

MENZIES
WESTERN AUSTRALIA



GEOLOGICAL LEGEND

AFTER TECTONIC MAP OF AUSTRALIA

- Geological boundary
- Interpolated trends of bedding, foliation etc
- Syncline

AFTER WESTERN AUSTRALIA, GEOLOGICAL SURVEY, BULLETIN 45

- Geological boundary
- Bedding strike and direction of dip
- Dyke or vein: q – quartz

ARCHAEAN
- A — Undifferentiated (mostly granite or gneiss with some meta-volcanics and meta-sediments)
- gn — "Greenstones"

GEOLOGICAL REFERENCE

A | B

A Western Australia, Geological Survey, Bulletin 45

B Tectonic Map of Australia

GEOPHYSICAL LEGEND

50 / 100 / 150 — Radiometric contours (no contours are shown where radiometric profiles have been interpolated)

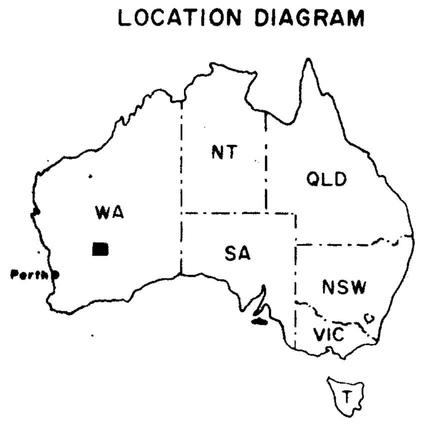
34 ⊗ — Radiometric anomaly restricted source (anomalies are numbered for reference only)

TOPOGRAPHICAL LEGEND

- River or creek
- Highway
- Road or track
- Railway
- Named place
- Homestead
- Hill feature
- Rock feature

BASED ON H51/80-5
BASED ON H51/81-60

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

YOUANMI	LEONORA	LAVERTON
BARLEE	MENZIES	EDJUDINA
JACKSON	KALGOORLIE	KURNALPI

AIRBORNE SURVEY, MENZIES-LEONORA, WA 1964

RADIOMETRIC RESULTS AND GEOLOGY

MILES 4 0 4 8 12 16 20 MILES

KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

RADIOMETRIC CONTOUR INTERVAL 50 COUNTS PER SECOND

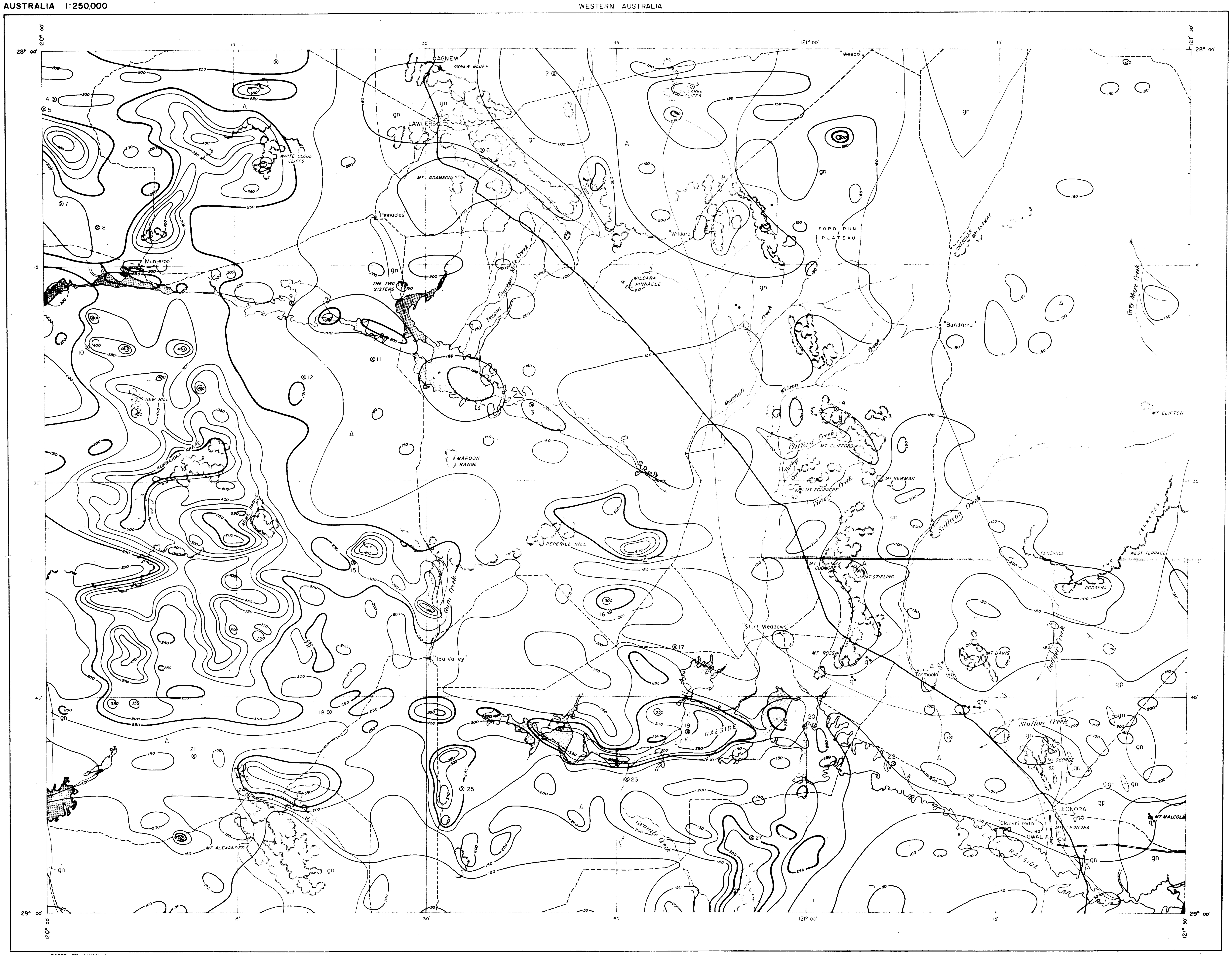
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. H51/B1-36
To accompany record No 1966/15

AUSTRALIA 1:250,000

LEONORA

WESTERN AUSTRALIA

PLATE II



BASED ON H51/80-3
BASED ON H51/81-61

GEOLOGICAL LEGEND

AFTER TECTONIC MAP OF AUSTRALIA

Geological boundary

ARCHAEAN
- A — *Undifferentiated (mostly granite or gneiss with some meta-volcanics and meta-sediments)*
- gn — *"Greenstones"*

AFTER WESTERN AUSTRALIA, GEOLOGICAL SURVEY, BULLETINS 45 AND 84

Geological boundary

Bedding, strike and direction of dip

Dyke or vein: quartz – q, jasper – qfe

Quartz blow

METAMORPHOSED SEDIMENTARY ROCKS — as — *Andalusite*

OLDER IGNEOUS ROCKS — gn, sp — *"Greenstones"* { *Derivatives of dolerites and gabbros*; *Serpentine* }

qp — *Contemporaneous acid rocks* { *Foliated quartz porphyries (granite schists)* }

LATER ACID IGNEOUS ROCKS — A — *Granite and contemporaneous porphyry and porphyrite dykes.*

GEOLOGICAL REFERENCE

A. Western Australia, Geological Survey, Bulletin 45
B. Western Australia, Geological Survey, Bulletin 84
C. Tectonic Map of Australia

GEOPHYSICAL LEGEND

50 / 100 / 150 — *Radiometric contours (no contours are shown where radiometric profiles have been interpolated)*

15⊗ — *Radiometric anomaly restricted source (anomalies are numbered for reference only)*

TOPOGRAPHICAL LEGEND

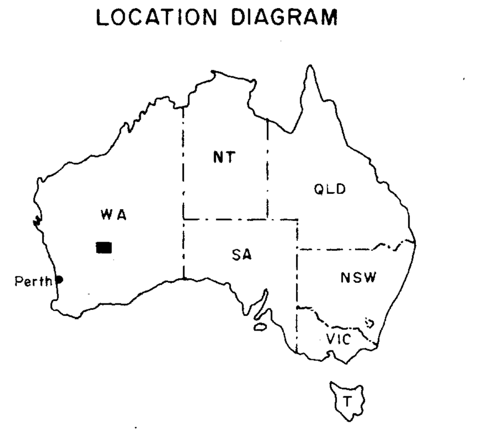
River or creek — *Named place*

Highway — *Homestead*

Road or track — *Hill feature*

Railway — *Rock feature*

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

SANDSTONE	SIR SAMUEL	DUKETON
YOUANMI	LEONORA	LAVERTON
BARLEE	MENZIES	EDJUDINA

AIRBORNE SURVEY, MENZIES-LEONORA, WA 1964

RADIOMETRIC RESULTS
AND
GEOLOGY

MILES 4 0 4 8 12 16 20 MILES

KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

RADIOMETRIC CONTOUR INTERVAL 50 COUNTS PER SECOND

Geophysical Branch, Bureau of Resources, Geology and Geophysics. H51/B1-35

To accompany record № 1966/15