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Record No. 1970 / 2

Sandstone and Youanmi Airborne Magnetic and Radiometric Survey,

Western Australia 1968

by

R.A. Gerdes, G.A. Young, B.F. Cameron and R.D. Beattie

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CONTENTS

ILLUSTRATIONS

SUMMARY

An airborne magnetic and radiometric survey of the SANDSTONE and YOUANMI 1:250,000 map areas was flown by the Bureau of Mineral Resources in 1968. The objects of the survey were to assist the systematic regional geological mapping of the Precambrian Western Australian Shield and the search for minerals.

Interpretation of the magnetic data is primarily qualitative. Geological strikes and the boundaries of major rock uhits have been interpreted by delineating magnetic trends, subdividing the area into zones of specified magnetic character, and assessing the significance of the zones with reference to mapped geology.

The areas are interpreted as consisting of heterogeneous acidic igneous masses with irregular basic regions and surrounding areas of interbedded basics and sediments. The correlation between the interpreted greenstone regions and known geology is reasonable. However, these regions appear to be more extensive than originally thought in some areas and less extensive in others. Additional regions in the north-east corner of SANDSTONE and the north-west and north-east of YOUANMI have been interpreted as greenstone.

Twenty-seven fold axes, seventeen induced and seven remanently magnetised dykes, and twenty-one faults have been interpreted. Areas which possibly include basic and ultrabasic rocks, which might be of economic importance, have been indicated.

The radiometric data reveal many high anomalies, most of which appear to be correlated with granite outcrops, breakaways, topographic features or salt lakes. Ninety-one radiometric anomalies produced by localised sources were detected. Nineteen of these anomalies warrant further ground investigation; four of them have amplitudes greater than ten times the standard deviation of the background radiation.

1. INTRODUCTION

In 1956 the Bureau of Mineral Resources, Geology & Geophysics (BMR) commenced an extensive programme of airborne magnetic and radiometric surveys in the goldfields region of Western Australia at the request of the Western Australian Department of Mines. The prime objective was to delineate the boundaries of major rock units which could serve as key horizons in the determination of geological structure. By the end of 1967 the 1:250,000 map areas of SOUTHERN CROSS*, KALGOORLIE, BARLEE, JACKSON, KURNALPI, WIDGIEMOOLTHA, BOORABBIN, NORSEMAN, LAKE JOHNSTON, MENZIES, LEONORA, EDJUDINA, LAVERTON, SIR SAMUEL, and DUKETON had been surveyed.

As a continuation of this programme, BMR carried out a survey of the SANDSTONE and YOUANMI areas, situated in the Murchison, East Murchison, and North Coolgardie Goldfields, between mid-July and mid-October 1968.

The survey area, bounded by latitudes 27°00'S and 29°00'S and longitudes 118°30'E and 120°00'E, constitutes a small part of the Archaean Yilgarn Block, a subdivision of the Western Australian Shield. The Block is essentially a vast mass of granite and gneiss, which encloses lenticular remnants of older rocks, folded about NNW axes. These remnants are composed of various interbedded lavas and sediments which were intruded by concordant basic and ultrabasic rocks prior to regional folding. The folding was accompanied by intrusion of the granite and by generally low-grade metamorphism. Mineralisation, of which gold has been the most extensively worked, is virtually confined to the folded older rocks.

The objectives of this survey were to aid a programme of systematic regional geological mapping of the shield and to assist in the search for metals. Regional mapping by the Geological Survey of Western Australia has been mainly directed towards the determination of the basic structure of the shield and with establishing a relation between such structure and mineralisation. A relation has also been sought between gold mineralisation and rock type, and the concept of 'favourable beds' and 'gold lines' is supported in much of the geological literature. Recent investigations by mining companies have been focused on a search for nickel deposits which could be associated with magnetically detectable ultrabasic rocks.

2. REVIEW OF PREVIOUS GEOPHYSICAL INVESTIGATIONS

Since 1956, airborne magnetic and radiometric surveys have been flown by BMR over the areas of KALGOORLIE, SOUTHERN CROSS,

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* Throughout this Record the names of 1:250,000 map areas are written in capitals to distinguish them from ordinary place names.

BARLEE, and JACKSON (Spence, 1958), KURNALPI and WIDGIEMOOLTHA (Carter, 1959), BOORABBIN and NORSEMAN (Forsyth, 1961), LAKE JOHNSTON (Wells, 1962), MENZIES and LEONORA (Young & Tipper, 1966), LAVERTON and EDJUDINA (Tipper, 1970), and SIR SAMUEL and DUKETON (Shelley & Waller, 1967). The magnetic data obtained from these surveys with the exception of the MENZIES, LEONORA, LAVERTON, EDJUDINA, SIR SAMUEL, and DUKETON areas, were interpreted by J.H. Quilty (personal communication), who found that significant geological structure could be outlined from contour maps of total magnetic intensity, the interbedded iron-rich rock units being traced as marker beds. A number of major folds and cross-folds were interpreted from the arcuate form of the magnetic trends. This interpretation was based on the conclusions of Ellis (1939) who had shown that the jaspilite outcrop pattern in the SOUTHERN CROSS area could be produced by strong folding followed by cross-folding of less intensity prior to peneplanation such that an 'hour-glass' pattern would be developed at the intersection of an anticline and a syncline.

Quilty also found that many cross-fold axes were outlined by a series of easterly trending anomalies, some of which extend over several hundred miles. Two types of cross-trending anomalies were recognised: intense negative anomalies attributed to remanently magnetised near-vertical sheets, and positive anomalies attributed to vertical sheets magnetised in a direction close to that of the Earth's present field. These sheets were interpreted as representing two or more suites of basic intrusives which possibly occupy tension fissures. Anomalies due to interbedded formations were considered to be of a form consistent with induced magnetisation. This assumption led to the calculation of susceptibility values mainly in the range 0.01 to 0.05 c.g.s., with a few as high as 0.2 c.g.s., Dip angles of the interbedded formations were found to be in the range 80° to 90° in all cases.

The magnetic data presented in profile form from MENZIES and LEONORA were interpreted by Young and Tipper (1966). Some aspects of regional geological structure were delineated by resolving and analysing magnetic trends and by subdividing the area into zones of specific magnetic character. Seven east-west dykes were defined with widths of 1000 feet, near-vertical dips, and depths of burial within 100 feet of the surface. Two of these dykes were interpreted as being remanently magnetised. North-south-trending anomalies of the order of 1000 gammas were calculated to represent susceptibility contrasts in the range 0.002 to 0.003 c.g.s. and these were attributed to serpentinite bodies. Larger anomalies approaching 10,000 gammas indicated jaspilites. Areas showing a relatively flat magnetic field were ascribed to near-homogeneous acidic igneous rocks or to non-magnetic sedimentary sequences.

The magnetic data obtained in profile form from the LAVERTON and EDJUDINA areas were interpreted by Tipper (1970). Practically the entire magnetic pattern was attributed to differences in magnetic properties between rock units at or near ground level. Geological strikes and boundaries of major rock units were interpreted by delineating magnetic trends, by subdividing the area into zones of specified magnetic character, and by assessing the geological significance of these zones with references to mapped geology.

The area was interpreted as consisting of heterogenous acid igneous masses with ill-defined more basic regions, which enclose elongate zones of interbedded sedimentary and basic rocks. Correlation with mapped geology was very good. Sixteen fold axes, one cross-fold axis, twelve major dykes (one remanently magnetised), and fourteen faults were delineated. Ultrabasic intrusions, thought to be of economic importance, were not resolved with absolute certainty by the magnetic pattern, but eleven areas with a high probability of containing these rocks were recommended for ground investigation.

Shelley and Waller (1967) found good agreement between the magnetic data and the mapped geology in SIR SAMUEL and DUKETON. However, the results suggest that the greenstone regions are more extensive than originally thought. Twenty-seven fold axes, four cross-fold axes, and one east-west fault were delineated, but no transverse dykes were located.

Interpretation of airborne radiometric data from the goldfields region indicated that most of the anomalies detected may be correlated with granitic outcrops. However, in the Southern Cross-Kalgoorlie region 84 anomalies were recommended for ground investigation following a low-level airborne radiometric survey (Mulder, 1960). Sixty-four radiometric anomalies were detected in MENZIES and LEONORA and of these, 47 were considered to warrant ground investigation (Young & Tipper, 1966). The radiometric data obtained in LAVERTON and EDJUDINA (Tipper, 1970), and SIR SAMUEL and DUKETON (Shelley & Waller, 1967) revealed many anomalies, which were mainly associated with granitic outcrops, but of which, 51 and 39 respectively were recommended for ground investigation.

3. GEOLOGY

Introduction

The survey area forms part of the Archaean Yilgarn Block, a subdivision of the Precambrian Western Australian Shield. The broad regional geology of this shield has been given by Forman (1953), Wilson (1958), and Prider (1948, 1954, 1961, 1965). The general sequence of Precambrian history is as follows. Basalts (often spilitic) and minor rhyolite flows were extruded onto an ancient basement surface. Pillow lavas indicate that there was considerable submarine vulcanism. Interbedded shale, greywacke, tuff, agglomerate, and banded iron formations (jaspilite) show that sedimentation was active during periods of volcanic quiescence. The lavas and sediments were intruded concordantly by gabbro, dolerite, ultrabasic rocks, and some minor porphyry. All these rocks were then folded about NNW-trending axes, contemporaneously 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, Compston, Jeffery & Riley, 1960). Gold mineralisation is probably genetically related to the granite (McMath, 1953; Campbell, 1965) and in parts of the shield the age of mineralisation has been dated as 2300 to 2400 million years (Wilson et al., op. cit.). A system of subordinate folding about ENE to NE axes was superimposed on the major folding and, in at least some parts of the shield, was a significant factor in localising gold mineralisation (Ellis, 1939; McMath, op. cit.). This cross-folding could be broadly contemporaneous with the major folding. Intrusion of cross-trending dolerite dykes marked the end of Precambrian time.

In much of the geological literature (e.g. Forman, 1953; Low, 1960), sections of the Archaean succession that are predominantly basaltic have been referred to as the Greenstone Phase or the Older Greenstones, and more sedimentary sequences as the Whitestone Phase or the Whitestones. Recent work in the Kalgoorlie-Norseman area (Horwitz & Sofoulis, 1965) has shown that the sediments and volcanics have a similar age, with basic igneous rocks interfingering with and passing laterally into sediments. The pre-folding intrusives have been referred to as the Younger Greenstones. A number of writers (e.g. Prider, 1965) have divided the granites into a gneissic Older (synkinematic) Granite and an intrusive Younger (postkinematic) Granite. Horwitz (1966) recognised two predominant granite facies - a medium to fine-grained equigranular granite and a coarser, porphyritic variety - which show contradictory age relationships and which may have wide, gneissic margins of mixed sedimentary and granitic origin. He regards the granites (as does Wilson, 1958) as being broadly contemporaneous and, in detail, of several ages.

The banded iron formations have been described by Miles (1941; 1943a and b; 1946; 1953), Connolly (1959), and Macleod (1965).

There has been no systematic mapping of the survey area, and recorded geological information is confined mainly to isolated gold mining centres. The geology of the survey area, given below, is based largely on the work of Gibson (1908a and b), Talbot (1912) Clarke (1914), and Feldtmann (1921; 1923). The geology (Plates 3, 4) was compiled from the map produced by Talbot and from the Geological Map of Western Australia (West Australian Department of Mines, 1966).

In this report, the term 'greenstone' is used to include rocks described in the above sources as derivatives of dolerite and gabbro, amphibolite, lava, and basic and ultrabasic intrusives. The term 'greenstone belt' refers to regions of interbedded sedimentary and basic igneous rocks, usually elongated along strike.

Stratigraphy

The major rock units and their distribution are described in order of decreasing age. It should be remembered that sedimentation commenced well before the end of igneous extrusion, and the sediments and lavas are generally interbedded.

Basement gneiss. The oldest rocks of the region are those of the ancient basement upon which the lavas were extruded. Honman (1917) believed that the basement was completely changed to granite and gneiss and suggested that some of the gneissic areas scattered throughout the granite might be relics of this basement. Although Clarke (1925) found variations within the main mass of granite, he could find no evidence that the gneissic patches are distinct from, and older than, the normal granite. Hobson (Hobson & Miles, 1950) found granitic pebbles in a conglomerate which is older than any granite, and he stated that these point to an ancient granite which has not yet been found.

"Older Greenstones". These are predominantly massive and sheared basic lavas, which have a wide distribution throughout the survey area. They range from fine- to coarse-grained epidiorite to amphibolite, which were derived from gabbro, dolerite, and quartz dolerite. Alteration involving chloritisation or carbonation is common. Gibson (1908a) recorded a small outcrop of hornblende andesite at Hancocks, four miles south of Sandstone, but subsequent petrological work (Clarke, 1914) suggests that it is a normal, amphibolised dolerite.

Sediments and metasediments associated with the Older Greenstones include jaspilite and related rocks. These generally crop out as conspicuous ridges and, being of sedimentary origin, can be used extensively for determining the broad structure of the area. They are divided into two main types - the ferruginous type and the siliceous type. The ferruginous type includes the typical red and black banded jaspilite consisting of alternating bands of chert and iron oxide (haematite and martite). Below the zone of oxidation these rocks consist essentially of fine-grained quartz and granular magnetite. The siliceous types are white to grey banded cherts.

Non-ferruginous sediments are apparently uncommon in the survey area. Quartzites and mica schists of presumed sedimentary origin crop out in Brooking Hills in the south-east corner of YOUANMI (Talbot, 1912). Feldtmann (1921) describes an area of gneissic and schistose rocks, enclosed by epidiorites, at Quinns in the north-west corner of SANDSTONE.

"Younger greenstones". Apart from medium to coarse-grained, diallagic, gabbroic rocks near Youanmi (Feldtmann, 1923, 1924) no basic or ultrabasic intrusives resembling the "Younger Greenstones" have been recorded in the survey area. In neighbouring areas, however, ultrabasic sills which include serpentinised rocks occur in belts which parallel the jaspilites.

Acid intrusives. Although granites occupy much of the survey area, their outcrop is poor. Esson (1925) records orthoclase granite associated with minor muscovite granite and gneiss, biotite granite, and pegmatitic granite to the west of Sandstone. At Youanmi the granite is predominantly quartz and feldspar with no biotite. These are the only reported compositions of the major granite bodies. However, they are probably similar to the potassic and sodic biotite granites in SIR SAMUEL (Shelley & Waller, 1967) and LEONORA (Young & Tipper, 1966).

Siliceous, chloritic schists enclosed by the granite at Barrambie, which superficially resemble normal greenstones, are thought to be derived from highly hornblendic granite or granodiorite (Gibson, 1908b).

Gneissic rocks are rare in the survey area, the largest outcrop recorded being a small area in the north-east of YOUANMI bordering LEONORA, shown in the Geological Map of Western Australia (1966).

Acidic dykes intrude the greenstones in many places near their contacts with the granite.

Basic intrusives (part-folding). The younger basic intrusives include various dolerites and lamprophyres. These occur as dykes which trend ENE and are associated with cross folds. These basic (dolerite) dykes weather readily and are usually observed only in mine workings.

Recent deposits. Alluvium and aeolian deposits cover much of the country.

Structure

The older Archaean rocks have been folded, producing a northerly to NNW regional strike, with dips usually greater than 65° east or west. Locally the strikes may vary by up to 90°, as at Sandstone, where some jaspilites strike E-W. No major folds have been reported and information on minor structures is sketchy. However, to the writers, the jaspilite outcrop pattern at Quinns suggests a NW-trending syncline superimposed on a larger, NE-trending anticline.

Cross-fractures striking E-W and infilled by quartz at Youanmi have been interpreted as normal faults (Feldtmann, 1924); some have apparently displaced the granite/greenstone contact by at least 450 feet and possibly up to 3000 feet. All other records of faulting are restricted to notes of minor fractures in individual mine workings.

The granite/greenstone contact, although locally crosscutting, broadly parallels the regional trend. In some areas it is marked by a zone of intense shearing of the greenstone.

Mineralisation

Gold and silver. The mineral most extensively worked in the survey area was gold, which in some places had associated silver. Most of the gold came from mines in the greenstones in the Sandstone-Hancocks area. Here the quartz reefs usually trend N-S and tend to become richer as the E-W-trending jaspilites are approached.

The other main mining centres in the survey area are Quinns, Youanmi, and Barrambie. At Quinns the reefs occur in both sheared metamorphic rocks and greenstones on what could be interpreted as cross-folding. The Youanmi orebodies are concentrated in highly sheared greenstones close to the granite, which may be penetrated for a small distance by some reefs. Well defined faults or shear lines parallel to the N-S strike of the chloritic schists controlled ore deposition at Barrambie.

Nickel. Prospecting for nickel is currently taking place in the survey area, but no finds have been reported to date.

4. MAGNETIC RESULTS AND INTERPRETATION

The magnetic data are displayed in Plates 2, 3, and 4. Plate 2 shows all profiles of total magnetic intensity related to a series of east-west lines which approximate the flight paths. A north-south scale exaggerated four times has been employed to improve data presentation. The profiles are accurately positioned with respect to longitude near longitudes 118°30', 118°48', 119°06', 119°24', 119°41' and 119°59'E. Idealised flight-lines were drawn as the mean straight line joining control points. The aircraft's ground speed was considered constant between any two adjacent control points on any one traverse. Intense magnetic anomalies are displayed at a scale of 5000 gammas per inch as compared to the scale of 500 gammas per inch used for most of the data. Plates 3 and 4 show every fourth east-west magnetic profile and selected tie profiles, together with the geological mapping to facilitate correlation. The interpretation of the magnetic data is given in Plates 5 and 6.

Virtually the entire magnetic pattern reflects near-surface lithological variations. An initial qualitative analysis of the data, involving the delineation of magnetic trends and the subdivision of the area into magnetic zones, was considered to be of particular value in satisfying the primary objective of the survey, namely to assist subsequent geological mapping. The magnetic parameters used as criteria to determine the zone-type are the degree of anomaly continuity from line to line (linearity) and the dominant amplitude range representative of each zone. The specified amplitude ranges were chosen by inspection of the overall anomaly pattern. An understanding of the limitations of such a classification is a prerequisite for assessing the geological significance of the zones. Accordingly these limitations are discussed in Appendix 1 together with the techniques employed in the quantitative interpretation of the magnetic data.

Analysis of magnetic trends

Plates 5 and 6 show a large number of magnetic trends, most of which extend for several miles with some up to 40 miles. The trends are concentrated in, though by no means confined to, the greenstone belts, and the direction of the trends shows good agreement with mapped geological strike. These observations confirm that many of the greenstone belts comprise regular, alternate bands of dissimilar rock types which can be traced along strike for many miles. It is also apparent that changes in trend direction are related to the folding of the strata.

A random selection of anomalies of simple form has been analysed. Virtually all depth determinations indicate that the magnetic bodies have apices within 300 feet of the surface. Most bodies have widths calculated in the range 500 to 2000 feet and dip generally at $90^{\circ} \pm 20^{\circ}$. Although some lower dips were recorded, all are steeper than 55°.

SANDSTONE area. In the western third of the area the dominant trend direction is north-west within the granite gneiss area. In the northern third of the area there is the dominant north-westerly trend of the greenstone belts and a roughly north-south trend in the areas mapped as granite and sediments. In the southern third of the area, the greenstones situated to the south-west and south-east of Lake Mason have a north-west trend. In the mapped greenstone belt around Sandstone, north-east and north-west trends are evident, which converge northwards about an east-west line south of Lake Mason. These trends suggest an anticlinorium near Sandstone. Divergence of trends north of this interpreted structure suggests a cross-fold axis. In the central eastern part of the area there is a definite north-easterly trend which extends for 24 miles.

YOUANMI area. In the southern half of the area, the dominant trend direction is north-south with secondary trend directions to the north-west and north-east in the south-western and south-eastern quarters respectively. In the north-eastern quarter the regional trend direction is at 340° veering to a north-westerly direction in the north. In the north-western quarter a general north-south strike direction is present in the extreme west, whereas to the east the dominant trend direction is at 020°. These two distinctive trend directions of 340° and 020° indicate the southerly continuation of the anticlinorium from SANDSTONE.

Magnetic zones and their significance

Tabulated below are the zone-types and a brief decription of their magnetic character. The anomaly range quoted for each zone-type includes most, but not necessarily all, of the anomalies in any zone of that type.

Zone type	Anomaly range	Magnetic linearity
1	less than 50 gammas	poor
2	50 to 100 gammas	poor
3	100 to 200 gammas	poor
4	greater than 200 gammas	poor
5	less than 100 gammas	good
6	100 to 250 gammas	good
7	250 to 500 gammas	good
8	500 to 4000 gammas	good
9	greater than 4000 gammas	good

Type-1 zones are interpreted as being either non-ferruginous sedimentary sequences or near-homogeneous acidic igneous masses. Irregularly shaped type-1 zones surrounded by zones of types 2 and 3 almost certainly represent the igneous masses, whereas the more regularly shaped type-1 zones elongated in the direction of geological strike and occurring between zones of types 5, 6, 7, and 8 are likely to signify the sedimentary sequences interbedded with more iron-rich formations. Irregularly shaped type-2 zones probably represent rocks of slightly more basic composition than those of type 1 (i.e. acid to intermediate).

Type-3 zones occurring in regions mapped as granite are probably caused by igneous rocks of intermediate to basic composition such as granodiorite, syenite, and diorite. The increase in basicity could be due to regional metamorphism, to assimilation of pre-existing basic rocks by the granite magma, or to granitisation, which has obliterated the original structural lineations. These zones may also represent gneissic sections within the granite bodies.

Where type-3 zones occur in the greenstone belts, they usually occur elongated in the direction of the geological strike and between zones of types 1, 2, and 5. These represent iron-rich sedimentary units, basic lavas, or minor intrusives in the sediments.

Type-4 zones, characterised by random high-amplitude magnetic distrubance, are variable in size and shape and are typical of irregularly shaped major basic and ultrabasic intrusives. Those delineated in the areas mapped as greenstones possibly represent structurally complex basic rocks and jaspilites with no clearly recognisable linearity.

Zones of type 5 and 6 cannot be attributed to any specific rock type, but probably represent stratigraphic sequences of alternating (intermediate to basic) lavas and sedimentary rocks or contact metamorphosed sediments. The transition between the two zones is not definite and is probably due to a combination of increased basicity and greater width of the magnetic strata. Where narrow zones of these types occur in granites, they may be caused by basic pegmatites and dykes. Wide zones of types 5 and 6 situated in granite regions probably represent areas of partially assimilated greenstones meterial.

Bedded basic lavas and sediments are interpreted as the source of type-7 zones. The proportion of lavas is greater in these zones than in zones of types 5 and 6. Some of the type-7 zones which have considerable length and alternate along strike with zones of types 6, 8, and 9 are undoubtedly due to banded ironstone formations. In addition some lineations may be due to the occurrence of tabular bodies, or a series of lenticular bodies, of basic or ultrabasic intrusives.

A large number of anomalies in the survey area exceeded 10,000 gammas. In the MENZIES-LEONORA area Young and Tipper (1966) subdivided the very high-amplitude anomalies into two distinct catergories: those of the order of 1000 gammas were interpreted as being due to serpentinite bodies, and those many times greater in amplitude were ascribed to banded iron formations. This simplification is now considered to be too strict, as overlap of the anomaly ranges of the two rock types have been observed. In SANDSTONE and YOUANMI, anomalies ranging from 500 to 20,000 gammas were subdivided into zones of types 8 and 9. Zones of type 9 are interpreted as banded iron formations. Although zones of type 8 may also include banded iron formations, known serpentinite bodies are included in this zone type, as indicated in Appendix 3.

In general, it is most probable that basic and ultrabasic bodies will fall within zones of types 7 and 8, whereas type-9 zones are produced by banded iron formations. Other zones which probably contain basic and ultrabasic bodies are those of types 4, 6, and 3 in decreasing order of importance. It must be noted, however, that anomalies associated with banded iron formations vary considerably in amplitude along strike, decreasing in places to those of a type-5 zone. This is due to lithological and/or width variations of the formations. Very long type-8 zones containing only one or two trend lines are probably due to banded iron formation, whereas wide zones containing many trend lines of limited length are more likely to represent a variety of rock types including banded iron formations, basic lavas and extrusives, and ultrabasic intrusives.

Comparison of zonal configuration and magnetic trends with mapped geology

Based on the interpreted zone-type/rock-type correlation discussed previously, it is possible to assess the agreement between mapped and interpreted geology, and to note the areas where conflicting geological and magnetic data indicate that further geological mapping is desirable.

SANDSTONE (Plates 5 and 7). Zones of types 1 and 2 predominate in the western region of SANDSTONE which is basically a granite-gneiss province with local areas of mapped greenstone. Such greenstone areas near Quinns and Pioneer Well are recognisable from the magnetic data as areas where zone types, 5, 6, 7, and 8 occur, but the greenstone area situated south of Yarrabubba is not so indicated. This last area lies mainly within a large type-1 zone, which was verified by ground investigation and from the radiometric data to be mainly an area of outcropping granite. Inspection of aerial photographs in the Quinns locality indicates that zones of type 8 and 9 mostly represent banded iron formations. A change in strike direction through Quinns corresponds to the mapped 'hematite bearing quartzites' of Gibson (1904) within the greenstones.

The type-7 zone situated south of fault f2 coincides with a feature evident in the aerial photographs. This may be a contact metamorphic zone between granite and greenstones. In the area near Pioneer Well, the magnetic data suggest that the greenstone is not as extensive as shown on the regional geological map.

Zones of type 5 and 6 situated within the granite-gneiss province of the western region generally trend 150° paralleling the regional strike of the greenstones. These zones are interpreted as representing either rafts of metasediments or compositional changes within the granite produced by injection gneisses or flow structures.

The central region of SANDSTONE incorporates a belt of greenstones, which has a mean width of approximately eighteen miles and which trends at 150°. The type-8 zone about Poison Hills coincides with a ridge visible on the aerial photographs and is interpreted as due to banded ironstones. Similar rocks in part account for the narrow zones of types 5, 7, 8, and 9 that trend at 150° through the mining areas of Errolls, Sugarstone, and Barrambie. Susceptibility measurements of samples from banded iron formations, haematite (specular) bodies, and chlorite schist collected from areas within these zones are listed in Appendix 3. The haematite bodies are contained within sediments paralleling the strike of chlorite schists between Sugarstone and Barrambie and within a type-5 zone. The westernmost trend in the adjacent type-8 zone at Barrambie may also be produced by these rocks.

The southward continuation of the type-7 and type-8 zones from Barrambie into the Sandstone greenstone area indicates a continuation of the chlorite schist and banded iron formation between Barrambie and Sandstone, beneath Cainozoic sediments.

The Sandstone greenstone belt is clearly delineated by the magnetic data. The magnetic zones east and west of Sandstone trend at 140° and 210° respectively, forming a fold structure which closes northwards. The apex of this fold occurs at Waukenjerrie Hill, from where a type-5 zone strikes at 330° to join the zones of types 7, 8, and 9 of the Barrambie greenstone belt.

Along the western edge of both type-6 zones to the north-east and north-west of Sandstone, geological boundaries may be inferred from aerial photographs. These zones probably correspond to either schistose metasediments with local jaspilite along the granite/greenstone contact or bands of dominantly siliceous jaspilite with local areas rich in magnetite.

The converging type-8 and type-9 zones south-west of Double Creek correlate with distinctive lineated features visible on the aerial photographs. It is probable that banded iron formations outline an anticlinal structure in this locality.

The area west of the narrow, elongated type-5 and type-6 zones west of Old Gidgee and Gidgee, is interpreted as an area of greenstones with granite intrusion. The region south-west of Jasper Hills and east of the Sandstone anticline is interpreted as an area of both acid and basic volcanics interbedded with sediments.

The region south-east of Lake Mason is dominated by irregular zones of types 1 and 2, which are interpreted as granitic areas. This granite province is bordered to the west at longitude 119°30' by a type-5 zone and to the east by greenstones of the Booylgoo Range. These greenstones extend from south of f12 to north of Booylgoo Springs homestead, and are outlined by converging type-8 and type-9 zones, corresponding to jaspilite.

The type-6 and type-8 zones situated just south of Lake Mason indicate a northerly extension of the greenstone belt from the Booylgoo Range beneath the Cainozoic sediments. Rocks in the area to the east and west are interpreted as granites.

The Montague Range belt of greenstone is clearly defined by the magnetic data. Within this belt, the elongated type-8 and type-9 zones extending southwards through Mount Townsend and Mount Marion over a distance of 16 miles correspond to jaspilite. East of the southern end of the Montague Range and north of Lake Mason, the group of zones of types 5, 6, and 7 indicate an area of unmapped greenstones. The mapped greenstone area near the north-east corner of SANDSTONE is associated with type-7 and type-8 zones indicative of banded ironstones and basic lavas.

<u>YOUANMI</u> (Plates 6 and 7). In the north-west quarter, the magnetic results delineate an area of greenstone extending from Windsor Homestead to Wyemandoo Hill. The greenstone appears to be confined to the west of longitude 118°38' and hence does not extend as far east as shown by the geological boundaries marked in Plate 6. The magnetic data indicate that the regional strike in this area is generally north. The type-6 and type-7 zones suggest that this is an area of basic lavas and intrusives.

The region east of longitude 118°38' and west of Unaly Hill is mainly a granite area represented by large expanses of type-1 zones. The area of the type-2 zone, between Windimurra homestead and Unaly Hill, includes zones of types 5 and 6 striking 030°. This is interpreted as an area of granodiorite with areas of partially or wholly assimilated greenstone. However, existing geological mapping does not confirm this interpretation.

The magnetic data show that greenstones form a continuous belt from Youanmi to Black Range as compared with the isolated occurrences indicated by the geological boundaries in Plate 6. The north-western boundary of this belt is more clearly delineated than the south-eastern one. Numerous type-5 zones occur along the latter boundary, and are interpreted as the metamorphosed contact zone between granite and greenstone.

The arcuate type-7 zones that pass through Nunngarra and Hancocks, correlate with a series of known banded iron formations (Gibson, 1968a). South of these zones, zones of types 6, 7, and 8 are generally arcuate and outline part of the interpreted Sandstone anticlinal structure. The high order zones within this region are thought to correspond to a number of rock types such as banded iron formations, dolerite dykes, and epidiorites as mentioned by Gibson (op. cit.).

Inspection of aerial photographs indicates that banded iron formations are the sources of type-8 zones about Dundaraga homestead, Mount Breen, and Mount Dwyer. Photographs also suggest that the zones of types 6, 7, and 8 that form belts trending at 140° from Black Hill and Rocky Creek to Maynard Hills contain banded iron formations.

The more easterly of these belts, which passes through Rocky Creek, correlates with greenstone lenticular belts mapped by Talbot (1912) south of that locality and at Maynard Hills. The type-6 and type-7 zones situated at Maynard Hills correspond to jasper bands within the mica and quartz schist (?) flanked by crushed granite (Talbot, op. cit.). These two greenstone outcrops appear from the magnetic data to represent a continuous narrow body about 0.8 miles wide which extends for 40 miles and dips at a moderate angle to the west.

The western belt of zones of types 6, 7, and 8 converges grandually to the south-east with the Rocky Creek-Maynard Hills belt. The northernmost type-8 zone corresponds to a lenticular greenstone area east of Maninga Marly as mapped by Talbot (op. cit.).

The type-3 zone located between these two converging belts of zones of types 6, 7, and 8 extends over a distance of 40 miles in a 330° direction. This zone is interpreted as a belt of irregular basic lavas and sills interbedded with acid volcanics or sediments. However, there is no geological evidence to support this interpretation.

The granitic region east of the Rocky Creek-Maynard Hills greenstone belt is dominated by large type-1 zones, with local areas of type 2 and 3. The type-5 and type-6 zones that have a regional trend of 150° within this region, indicate either flow direction or relict structures of assimilated greenstones. The type-5 zone, that trends at 010° near the north-eastern corner of YOUANMI is characteristic of a basic dyke intruding the granitic material.

South of Maynard Hills, the magnetic zones show a general change in direction from 150° to 180°. The magnetic data indicate an area of greenstone similar to that shown by geological mapping in the Brooking Hills-Mount Forrest locality.

The type-9 zone through Mount Alfred, which trends north-south along the eastern boundary of the survey and forms a sigmoidal trend through Mount Forrest, corresponds to series of banded iron formations interpreted from the aerial photographs.

West of Mount Alfred, the zones of types 5, 6, 7, 8, and 9 show convergence to the north and south, indicative of a closed fold in greenstones. The type-1 zone inside the closed structure probably corresponds to metasediments and/or acid volcanics. The type-1 zone that extends in a north-south direction between the Brooking Hills and the closed fold structure is granite, as recorded by Talbot and indicated by radiometric data.

The greenstone belt east of Cashmere Downs homestead and south-east of Horse Fall Rocks is represented by a complex group of zones of types 7, 8, and 9 which trend at 340° and are surrounded by a large type-1 zone. This type-1 zone probably represents an area of either sediments or acid volcanics, with the discontinuous series of type-5 and type-6 zones representing a metamorphic contact zone between the granite and greenstone. This interpretation implies a greater extent of greenstones than shown by current geological mapping. Aerial photographs reveal that outcrops in these zones of types 5 and 6 have low relief and strong lineations, similar to granite outcrops at Horse Fall Rocks.

Magnetic data indicate that the region about Lake Barlee between the two greenstone belts is dominated by a type-3 zone, representative of this granitic area. This zone is subdivided by the prominent 025° trends, which coincide with hills having the same general strike. These trends are interpreted as representing either basic intrusives or relict structures within the granitic mass.

The central region south of the Sandstone-Hancocks-Nunngarra greenstone area is a granite-gneiss province with zones of types 1, 2, and 3 predominating. The type-3 zones situated south and south-west of Maninga Marly are interpreted as basic instrusions. The small type-4 zone situated ten miles WNW of Bulga Downs is probably an ultrabasic body. The two large type-3 zones that extend southwards for 32 and 36 miles respectively within the south-east quarter of the map are interpreted as rocks of intermediate composition within the granite province.

In the south-west quarter, most of the areas mapped as greenstone appear to have a granitic character as shown by the magnetic data. The greenstone belt from Black Range to Unaly Hill continues through Youanmi to the south of Younangarra homestead. A widening of this belt occurs between Youanmi Downs and Yuinmery homesteads, where northerly and southerly convergence of the magnetic zones east of Youanmi form a closed fold structure.

Tye type-1 zone that separates the two resolved greenstone areas at Youanmi Downs homestead is interpreted as a granite intrusion. The small type-5 zone situated south-east of Youanmi, trending at 010°, corresponds to a lineament which is apparent on the aerial photographs and follows the contact between the granite and greenstone.

The complex belt of magnetic zones west of Youanmi and Younangarra homestead outlines the extent of greenstone and shows both a northerly and a southerly convergence of the zones. Although the significance of the type-7 and type-8 zones is unknown, basic schist(?) and serpentinised pyroxenite have been reported to the south of Younangarra homestead within the type-5 zone (Talbot, 1912).

The type-5 and type-6 zones situated south of Younangarra homestead are interpreted as representing a southerly extension of the greenstone. The area west of the greenstone belt at Youanmi is dominantly a granitic area, represented by type-1 and type-2 zones. The type-3 zone situated south-west of Younangarra probably corresponds to granite with assimilated greenstone. The type-5 and type-6 zones trending at 020° near the southern boundary of the survey are interpreted as basic dykes.

The area east and south-east of Youanmi is mainly a granitic area as shown by the type-1 and type-2 zones, The type-5 and type-6 zones that strike generally at 340° are most probably a region of wholly or partially assimilated greenstone or gneiss.

Structure

The interpreted fold axes and faults are shown in Plates 5 and 6, based on magnetic and photogeological interpretation. Plate 7 illustrates the regional structure determined within the entire survey area.

SANDSTONE (Plate 5). Most of the fold axes delineated are located within the central and eastern greenstone belts.

East of Inglewood homestead, the convergence of type-5 and type-6 zones indicates a fold structure which is interpreted as either a northerly pitching anticline or a southerly pitching syncline.

In general the magnetic data indicate that the central greenstone belt consists of a complex series of pitching folds, whose axial planes broadly parallel the regional strike direction of 330°. The belt is seen to consist of two anticlinal regions separated by a synclinal region with an erea of east-west cross-folding between Barrambie homestead and Waukenjerrie Hill.

Zonal configuration about Sandstone together with photogeological interpretation indicate the presence of a highly folded anticlinal structure, i.e. an anticlinorium, which pitches northwards. Farther north about Waukenjerrie Hill the characteristic 'hour glass' structure apparent in the magnetic data is attributed to the intersection of two fold axes at right angles.

Similar analyses of zonal trends and photogeological interpretation indicate anticlinal axes which pass west of Barrambie homestead and continue northwards with local offsetting by faults, and others which occur between Jasper Hills and Wyooda Thangoo Hills.

In the eastern region of SANDSTONE, two large greenstone belts are located along the Booylgoo and Montague Ranges. The Booylgoo Range belt is clearly defined by zones of types 5, 6, 7, 8, and 9 which trend at 350°, and converge at their northern and southern extremities. These zones are interpreted as representing a closed pitching synclinal structure whose northern part is terminated by east-west faults.

Of 14 interpreted faults in SANDSTONE, nine coincide with pronounced east-west lineaments visible on the aerial photographs, viz. faults f1, 4, 5, 6, 8, 10, 12, 13, and 14. Fault f6 south of Barrambie is of particular interest as collinear with this interpreted structure are three small zones of type 4 indicative of basic or ultrabasic rocks. The concentration of east-west faults in the central part of SANDSTONE supports the interpreted east-west cross-fold system.

A number of dykes that exhibit either induced or remanent magnetisation were delineated in SANDSTONE. Their extent is much less than the major transverse dykes of the type located by Young and Tipper (1966) and Tipper (1970). Remanently magnetised dykes occur mainly in the western granite-gneiss area, and have an anomaly amplitude range between 100 and 500 gammas. Narrow, elongated type-5 zones, which have locally discordant strike directions of either 030° or 150°, are interpreted as dykes with induced magnetisation. Examples of such dykes are to be seen near the eastern boundary of the survey area.

<u>YOUANMI</u> (Plate 6). Fourteen fold axes were delineated in YOUANMI, most of which are located within known or interpreted greenstone belts.

The most outstanding structural element interpreted in YOUANMI is the anticlinorium outlined by two limbs trending in north-easterly and north-westerly directions which converge into SANDSTONE. Subsidiary folding is present in the limbs of this interpreted anticlinorium as evidenced by the syncline interpreted along the strike of the Maynard Hills greenstone belt. The axial region of the anticlinorium appears to have been granitised and intruded by granite. A large remnant greenstone fold belt situated between

Horse Fall Rocks and Lake Barlee has not been assimilated by the granite. This greenstone belt appears to form a closed fold structure which pitches to the north and south. The magnetic anomalies indicate this structure to be anticlinal. However, inspection of aerial photographs suggests a large north-south striking anticline in the east, with a complex of closely folded anticlines and synclines to the west. Deflection of the axial plane of the interpreted fold in the north and south indicates superimposed cross-folding.

A similar anticlinal axis is interpreted in the Mount Forest-Brooking Hills greenstone area. Small anticlinal and synclinal structures are formed by banded iron formations near Mount Forest. Closure of these structures to the north indicates an east-west cross-fold.

North of the Maynard Hills, the interpreted fold structures converge into the Sandstone anticlinorium. The central apical region is dominated by arcuate type-7 zones interpreted as banded iron formations. South of this arcuate zone, zonal configurations indicate complex folding and perhaps faulting. The type-8 zones situated around Mount Breen and Mount Dwyer correspond to very highly folded units visible in aerial photographs.

The magnetic zones situated in the Black Range and Tabletop areas have a dominant 020° strike and constitute the western limb of the Sandstone anticlinorium, which extends southwards into the Younami mining area. An anticlinal structure is interpreted between Youanmi Downs and Yuinmery homesteads together with two indeterminate folds to the west and east.

Seven faults were delineated from magnetic data in YOUANMI, three of which coincide with east-west lineaments visible on the aerial photographs, viz. faults f15, 16 and 19. Fault f21 is delineated over part of its extent by a type-5 zone.

Remanently magnetised dykes delineated in YOUANMI are restricted to the northern part of the area. They have similar magnetic character and extent to those found in SANDSTONE. Zones of type 5 which appear to be discordant with regional strike are again interpreted as due to normally magnetised dykes, examples of which are clearly evident north of Lake Barlee and east of Rocky Creek.

5. RADIOMETRIC RESULTS AND INTERPRETATION

Radiometric data were obtained using two scintillometers. The inboard scintillometer, set with a time constant of ten seconds, was used to record broad variations in radiometric intensity with a view to assisting geological mapping. Equipment failure restricted the operation of a 'towed bird' in the normal lowered position to lines 168-195. For these lines, a time constant of one second was used for the outboard scintillometer to detect restricted sources of radioactivity. On all other lines the outboard scintillometer was operated in the retracted position with a time constant of two seconds, appropriate to the greater detector altitude of 500 feet above ground level.

Inboard scintillometer

A contour presentation of the radiometric data, superimposed on mapped geology, is shown in Plates 8 (SANDSTONE) and 9 (YOUANMI). Some smoothing of the contours was necessary to reduce distortions caused by such errors as: parallax due to delay in instrument response resulting from the ten-second time constant, temperature-affected instrument drift, variation in instrument sensitivity, positional error identical to that of the magnetic data, and errors due to variations in aircraft-to-ground clearance.

Much of the SANDSTONE and YOUANMI area has radiometric values less than 50 counts per second (c.p.s.) and most of the area is below 100 c.p.s.. However, some highs exceed 300 c.p.s..

In both SANDSTONE and YOUANMI the radiometric data are of limited value as a guide to rock distribtuions. Granitic rocks are most common, and variations in composition, depth of weathering, and soil cover would account satisfactorily for the broad variation in the radiometric results. As could be expected, there is some correlation of radiometric highs with known granite outcrops, for example the outcrop north-east of the northern end of the Booylgoo Range, the area directly south of the eastern end of Lake Mason, and also near Yarrabubba homestead (Plate 8).

In general no apparent distinction can be observed between the radiometric results associated with granite and those associated with greenstone in this area. Although the Booylgoo Range in the south-east of SANDSTONE is delineated by a distinct radiometric low, the Montague Range, which has a similar greenstone geology, does not produce any characteristic anomaly. A small greenstone outcrop (Plate 9), east of Rocky Creek in YOUANMI gives rise to several discontinuous radiometric highs.

The radiometric data, despite their unsystematic relation to known geology, show a marked agreement with certain topographic features. It has been previously noted (Young & Tipper, 1970; Shelley & Waller, 1967) that strong positive anomalies occur over dry salt lakes and claypans. Young and Tipper (1966) suggested that the anomalous values over salt lakes may be caused by the presence of the isotope potassium-40 in salt concentrations.

In SANDSTONE and YOUANMI, radiometric highs are also commonly associated with breakaways. The formation of the breakaways involves the stripping of superficial material such as soil, laterite, and kaolinised granite from the underlying rock. This underlying rock will be granite in many places, and hence the anomalies over breakaways may be due merely to local thinning of the overburden over granite.

In the north-west of SANDSTONE, the large dry salt lake near Quinns mine (Plate 8) is clearly marked by a radiometric high, as is the elongate north-trending lake to the east and south of Yarrabubba homestead. The latter feature produced very strong anomalies on the outboard scintillometer. In the north-east of SANDSTONE, there is a NW-trending positive anomaly over a salt lake which is clearly visible on the air photographs. To the south of this feature the 100-c.p.s. contour follows the edge of a series of breakaways. Lake Mason, however, which was filled with water at the time of the survey, is an area of distinct radiometric lows.

In YOUANMI the large lake in the centre of the area and Lake Barlee in the south are marked by both high and low radiometric values, according to the occurrence of dry and water-covered areas.

Outboard scintillometer

A total of 91 anomalies from restricted sources were located in this area: 61 in SANDSTONE and 30 in YOUANMI. These are listed in Appendix 2, and the criteria used in selecting them are also discussed in Appendix 2. Several anomalies listed in Appendix 2 are too wide to satisfy the point-source criteria but were retained because of their high amplitude; these anomalies are indicated by an asterisk.

The following figures illustrate the correspondence between point-sources and surface features in this area.

	Number of Point-sources	
	SANDSTONE	YOUANMI
Breakaways	19	6
Salt lakes (dry)	14	5
Remainder	28	19

Thus half the point-sources discovered in the survey area are related to salt lakes or breakaways. Of the remaining 47 anomalies, seventeen are of type A and two are type B (See Fig. 1). These are the only anomalies considered worthwhile for ground investigations in the area. They are indicated by the letters G.I. in Appendix 2.

6. CONCLUSIONS AND RECOMMENDATIONS

The boundaries of interpreted greenstone belts as shown in Plates 6 and 8 correlate with those of the mapped greenstone belts in only a few places. Although in both SANDSTONE and YOUANMI the magnetic results suggest that the greenstone regions are generally more extensive, a few greenstone regions appear to be less extensive than mapped.

In SANDSTONE, the magnetic data indicate that the western region is mainly a granite-gneiss province with greenstone delineated at Quinns and Pioneer Well. The central greenstone region has been clearly delineated; however, the distribution and structure of these rocks differ from that mapped. In the eastern region, greenstones of the Montague and Booylgoo Ranges are clearly delineated by the magnetic data but appear to be discontinuous north and south of Lake Mason. An interpreted greenstone belt in the north-east corner of SANDSTONE warrants ground investigation to confirm its presence.

In YOUANMI, the magnetic data indicate that the eastern boundary of the greenstone belt about Windimurra and Windsor homesteads should be located approximately seven miles west of its mapped position. The region of greenstone around Youanmi has been interpreted as forming two closed structures. The more eastern of those structures is located as the southern extremity of an interpreted greenstone belt which forms the western limb of an anticlinorium interpreted as having its centre on Sandstone. The eastern limb of this major structure is evident as a continuous greenstone belt, which extends into the Brooking Hills region. The greenstone belt situated east of Cashmere Downs homestead appears to be more extensive than that mapped. The main structural elements of this region, together with the distribution of the major rock types, are shown in Plate 7.

Zones of type 9 which occur in the greenstone belts are interpreted to be due to banded iron formations (jaspilite). Although similar rock types alwo occur in zones of types 7 and 8 it is probable that basic and ultrabasic bodies occur in these zones. Other zones of probable basic and ultrabasic significance are zones of types 4, 6, and 3 in decreasing order of significance. Plate 8 indicates the areas containing the above mentioned zones, which warrant further investigation in the search for economic nickel mineralisation.

The radiometric data recorded by the inboard scintillometer appear to be of limited value in assisting geological mapping. Ninety-one radiometric anomalies which satisfy the 'point-source' criteria were detected by the outboard scintillometer and half of these related to breakaways or salt lakes. Of the remaining 47 anomalies, only 19 are considered worthy of ground investigation.

The survey succeeded in providing information that should be of considerable assistance to regional geological mapping and the search for minerals. It is considered that the magnetic data will admit of a more detailed and positive interpretation as more geological mapping is carried out in the area.

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APPENDIX 1

INTERPRETATION PROCEDURE

Qualitative magnetic interpretation

The magnetic data have been qualitatively analysed by delineating magnetic trends and zones. A magnetic trend by definition joins the peak positions of anomalies which are attributed to one continuous magnetic body, such that the trend parallels the strike of the causative body. Except for perfectly symmetrical anomalies, however, a trend will not coincide with the apical axis of the body. This axis will generally be situated towards the negative part of the anomaly by an amount which is a function of the body's dip and strike angles.

Magnetic zones are based on the criteria of the degree of magnetic linearity and the dominant anomaly amplitude range, as described in Chapter 4. These criteria, although generally satisfactory for distinguishing between contrasting rock types, introduce limitations to zonal significance when the zones are derived from profile data only. These limitations must be considered when attempting to equate zones and geology. The linearity criterion is used to distinguish between formations containing similar percentages of ferromagnetic material but of greatly differing genesis and mineral potential. A series of interbedded lavas and sediments, for example, can produce anomalies with amplitudes equal to those produced by irregular masses of ultrabasic rock contained in granite. The magnetic trend criterion would generally clearly differentiate between the two cases. Recognition of anomaly trends, however, requires a reasonably large angle between geological strike and the flight path direction; thus a type-3 zone could in fact represent a perfectly regular interbedded sequence striking near-parallel to the flight paths. Magnetic trends are difficult to delineate also when two or more strike directions are represented in the one region, and in areas of small-scale structural deformation.

Significance of the amplitude criterion should be assessed with the knowledge that amplitude is a function not only of magnetic susceptibility contrasts but also of width, depth, and strike of the body. To be able to more accurately equate zones and lithology, the zones would need to be based on susceptibility values calculated for each anomaly, but time has not permitted this procedure.

Certain structural features have been interpreted from zonal configuration. Faults were interpreted from the co-linear termination of magnetic zones and trends or from abrupt changes in trend direction. Where a folded sequence contains one or more magnetic horizons, the fold has been interpreted from a repetition of zones and individual anomalies. Where possible, dip analyses have been used to determine the sense of the folds.

Quantitative magnetic interpretation

The determination of depths, widths, dip angles, and apparent susceptibility contrasts of selected anomalies was based on the assumption that the magnetisation is wholly induced. As the magnetic data are in preliminary form containing an inherent positional inaccuracy, quantitative interpretation was restricted to those anomalies where the local magnetic trend direction could be accurately measured.

Depths of magnetic bodies below detector level were obtained by several methods. With anomalies of simple form showing no partial resolution, depths were rapidly calculated using the half-maximum-slope technique advocated by Peters (1949) and extended by Moo (1965). The depth of burial of magnetic bodies was obtained by subtracting the recorded aircraft's ground clearance from the total calculated detector-to-body distance. Widths were obtained by measuring the horizontal distance between the two inflection points on the limbs of an anomaly. This method is quite accurate except where actual width is less than twice the detector-to-body distance, in which case the calculated width represents a maximum possible. Where practicable, more accurate width determinations were made by reference to Bean (1966) and Moo (1965).

Susceptibility contrasts were calculated using standard formulae given by Reford and Sumner (1964). The values calculated for banded iron formations must be regarded as only approximate. The amplitude of an anomaly associated with an iron formation depends on many factors which are considered in calculations, but it depends also on the arrangement of magnetite in the rock. A considerable susceptibility anisotropy can exist in banded iron formations. Jahren (1963) has shown that layered iron rock can have a susceptibility as much as three times greater parallel to the layers than at right angles to the layers. Also, the 'along-the-layer' susceptibility of a bedded sample containing one percent magnetite was found to be three times as great as that of a homogeneous sample of the same overall magnetite content (Jahren, op. cit.).

Dip angles were obtained using the techniques of Moo (1965) and Bean (1966).

APPENDIX 2

INTERPRETATION OF OUTBOARD RADIOMETRIC DATA

For an anomaly to be resolved from the normal gamma-ray background noise, the amplitude must be statistically significant. The acceptance level adopted is three times the standard deviation (S.D.) of the background noise. Two distinct types of gamma-ray background noise are recognised:

'Statistical noise' is a statistical variation of the gamma-ray intensity recorded while flying over a homogeneous radioactive source; its standard deviation is given by:

$$S.D. = (N/2T)^{\frac{1}{2}}$$

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

'Geological noise' is a variation of the gamma-ray intensity recorded while flying over a heterogeneous radioactive source, e.g. a granite covered by varying thicknesses of weathered rock and soil.

As a result of experience it is considered that combined statistical and geological noise lies within an envelope whose height is four times the standard deviation of the recorded signal. This argument is used in reverse to estimate the standard deviation, as follows. A smoothed envelope is drawn on the magnetic record to enclose all peaks and troughs that are judged to be due to statistical or geological noise; the height of this envelope is then 4 x S.D.. Any peak that departs from the median line of the envelope by more than 3 x S.D. is classed as a significant anomaly.

Having determined which anomalies are significant with respect to noise, it is important to distinguish those due to small bodies ('point sources') of strongly radioactive material from those due to large bodies of only weakly radioactive material. This is done by examining the shape of the recorded anomaly. Anomaly shape is a function of the source/detector geometry and of the instrumental time constant of the detector. The width (w) of an anomaly at half peak amplitude is related to these factors, and the following criteria were adopted to distinguish point-source anomalies:

Height of detector above ground level	Time constant	Point-source criterion: w must lie between
240 feet	1 second	3 and 4.5 seconds
500 feet	1 second	3.5 and 6 seconds
500 feet	2 seconds	5 and 7 seconds

Here the upper limit of w ensures that the source is of small horizontal extent, and the lower limit of w acts as a further check on statistical significance. The point-source criterion can be satisfied by a continuous range of sources between the limits of (a) a source of zero radius located 300 feet from the flight path and (b) a source of 300-foot radius centred on the flight path.

Young and Tipper (1966) classified anomalies by visual inspection into four categories (A, B, C, D) based on their significance with respect to statistical noise, local geological noise, and neighbouring geological noise. The same classification is used in the following table of results, and Young and Tipper's illustration is reproduced here (Figure 1).

Anomaly No.	Line No.	Fiducial No.	Half-peak width (sec.)	Amplitude (X S.D.)	Classification	Comments
SANDSTONE AREA						
1	107E	0278.5	5	5	A	salt lake
2	104E	0839.5	5.5	5	D	breakaway
3	107E	0388	5	8	D	
4	105W	1055.5	6	10	D	
5	109E	0889	5.5	10	C	
6	103W	0540	6	8	B	breakaway
7	104E	0962	5.5	6	D	
8	112W	1486.5	5	4	A	breakaway
9	112W	1503.5	5.5	8	A	salt lake
10	111E	1416	5	6	A	salt lake
11	114W	0347.5	5	7	B	G.I.
12	114W	0360	6	11	A	G.I.
13	113E	0142	5	6	A	breakaway
14	112W	1581	5	7	D	
15	111E	1322	5	11	A	G.I.
16	112W	1638.5	7	10	A	salt lake
17	126E	1006.5	6	10	A	breakaway
18	135W	0211	6	5	A	breakaway
19	135W	0202.5	6	8	B	breakaway
20	127W	1394	6	6	A	breakaway
21	123W	0412	6.5*	12	A	salt lake
22	124E	0549	7*	14	A	salt lake
23	125W	0892.5	7*	20?	A	salt lake
24	126E	1034	4.5	8	A	salt lake
25	128E	1558	6	14	B	salt lake
26	129W	1900.5	5	7	A	salt lake
27	140E	0553	6	5	A	breakaway
28	143E1R	0062	6	9	D	
29	120E	2039	5.5	8	D	
30	121W	2267	6	11	D	

APPENDIX 2 (contd.)

Anomaly No.	Line No.	Fiducial No.	Half-peak width (sec.)	Amplitude (X S.D.)	Classification	Comments
Sandstone Area (contd.)						
31	128E	1606	6	4	A	breakaway
32	129W	1855	4	9	D	
33	130E	0118.5	5.5	6	A	G.I.
34	135W	0134.5	5	5	C	breakaway
35	135W	0115	5	8	C	
36	136E	0385.5	5.5	8	A	G.I.
37	141W	0903	6	9	D	
38	140E	0611.5	5.5	8	A	breakaway
39	121W	2218.5	5	5	A	G.I.
40	118W	1275.5	5	9	D	
41	121W	2193	5	5	A	G.I.
42	127W	1223.5	3.5	5	A	breakaway
43	129W	1762	5	10	D	
44	132E	0668.5	6	11	D	
45	136E	0473	5	8	A	G.I.
46	141W	0803	6.5	5	A	salt lake
47	149E	0248	6	13	B	breakaway
48	151E	0697	6	7	B	salt lake
49	156W	0382	5.5	6	A	salt lake
50	159E	118.	7	9	D	breakaway
51	163W	0844.5	5	9	D	breakaway
52	169W	0356	4	6	C	
53	168E	0191	3.5	6	C	
54	167W	1789	5.5	4.5	C	breakaway
55	170E	0189	6	4?	A	breakaway
56	154W	1437	5	8	D	
57	159E	1044	6	11	D	breakaway
58	159E	1053	6.5	12	D	
59	169W	0440.5	4.5	8	C	
60	168E	0028	3	6	A	salt lake
61	168E	0212	6	16	D	
YOUANMI AREA						
62	174E	1025?	3.5	11?	A	G.I.
63	174E	1026	6	12?	A	G.I.
64	175W	1393	4	4	A	G.I.
65	173W	0915	5	9	A	breakaway
66	180E	1136.5	4.5	12	D	breakaway
67	186E	0561	3.5	5	A	breakaway
68	183W	1944	3.5	8	A	G.I.
69	185W	0380	4	7	A	G.I.
70	174E	1095	3.5	6	C	
71	179.1W	0844.5	3	7	D	

APPENDIX 2 (contd.)

Anomaly No.	Line No.	Fiducial No.	Half-peak width (sec.)	Aplitude (X S.D.)	Class-ification	Comments
YOUANMI AREA (contd.)						
72	201.1E	1623	7	12	B	Breakaway
73	206W	0781	7	11	D	salt lake
74	205E	0672	7	7	A	G.I.
75	210W	1755	7	7	A	G.I.
76	218W	1810.5	6	8	A	breakaway
77	225E	1662	7	8	B	G.I.
78	237E	0699	6	12	C	salt lake
79	224W	1313.5	5	11	D	
80	227E	0163	6.5	8	C	
81	228W	0337	5.5	6	A	G.I.
82	213E	0562	6.5	5	A	salt lake
83	219E	0140	6.5	10	C	salt lake
84	221E	0596	6.5	11	D	salt lake
85	222W	0844.5	7	5	A	G.I.
86	234W	1768	7	7	A	breakaway
87	225E	1523	7	7	A	G.I.
88	230W	0910.5	7	8	C	
89	233E	1473.5	7	9	D	
90	236W	0450.5	6	8	C	
91	236W	0421	6	6	C	

Notes

* indicates that the half-peak width is too great to satisfy the point-source criteria.

? indicates that the anomaly was off-scale and hence the values for amplitude and width are uncertain.

G.I. indicates that the anomaly is considered worthwhile for ground investigation.

APPENDIX 3

SUSCEPTIBILITY MEASUREMENTS

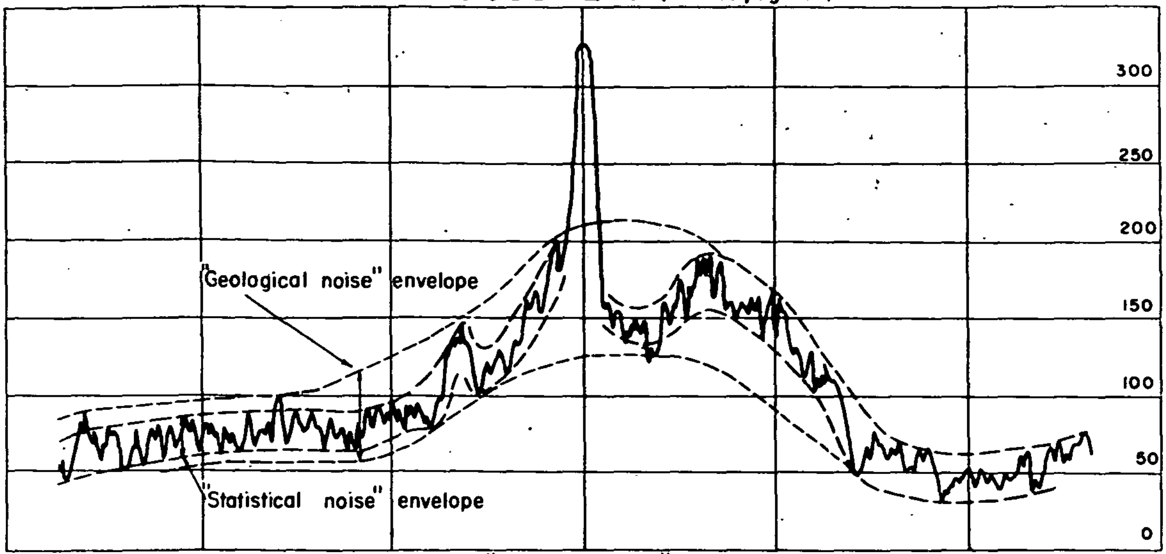
Tabulated below are volumetric susceptibility measurements of rock samples collected in or near the survey area. These measurements were made by use of a Sharpe SM-4 magnetic susceptibility meter.

Sample Locality	Rock type	Susceptibility c.g.s. units
Donkey Rocks (EDJUDINA)	Granite	250×10^{-6}
Yoo HS (SANDSTONE)	Granite	150×10^{-6}
EDJUDINA	Banded iron formations (quartz rich)	30×10^{-6}
"	" " " (normal)	$1,500 \times 10^{-6}$
"	" " " (magnetite rich)	$11,000 \times 10^{-6}$
Barrambie (SANDSTONE)	Greenstones including chlorite schists	100×10^{-6}
" "	Banded iron formation (Type-9 zone)	$1,400 \times 10^{-6}$
" "	Specular haematite	80×10^{-6}
Sugarstone mine (SANDSTONE)	" "	600×10^{-6}
" open cut	" "	$100-3,200 \times 10^{-6}$
Garden Gully (BELELE)	Gabbro	70×10^{-6}
"	Serpentinite	$3,800 \times 10^{-6}$
Belele HS (BELELE)	Serpentinised pyroxenite	$4,000 \times 10^{-6}$

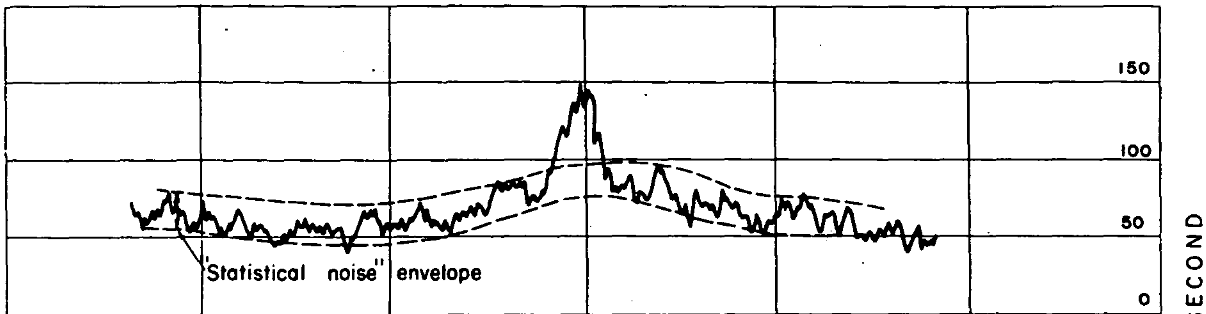
The variation in the magnetic susceptibilities of the specular haematite on the western side of a greenstone ridge at Sugarstone and Barrambie indicates varying degrees of weathering.

Magnetic anomalies associated with the ultrabasic rocks at Belele range in amplitude to 3500 gammas; i.e. within zone type 8 classification.

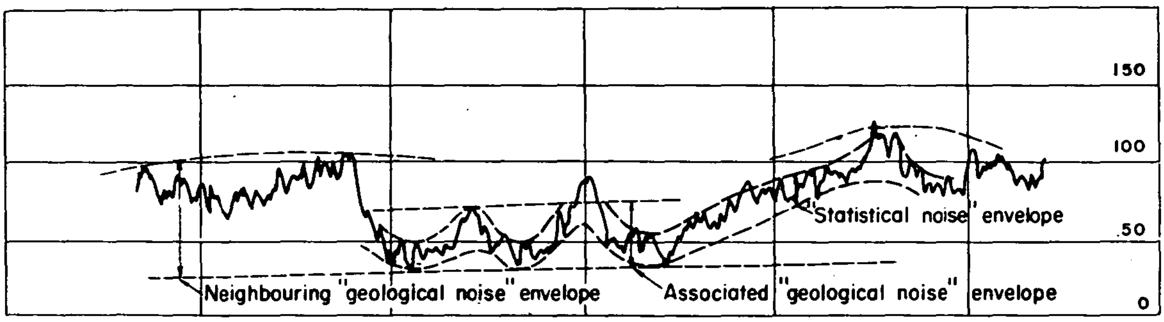
FIGURE 1 (To face page 29)



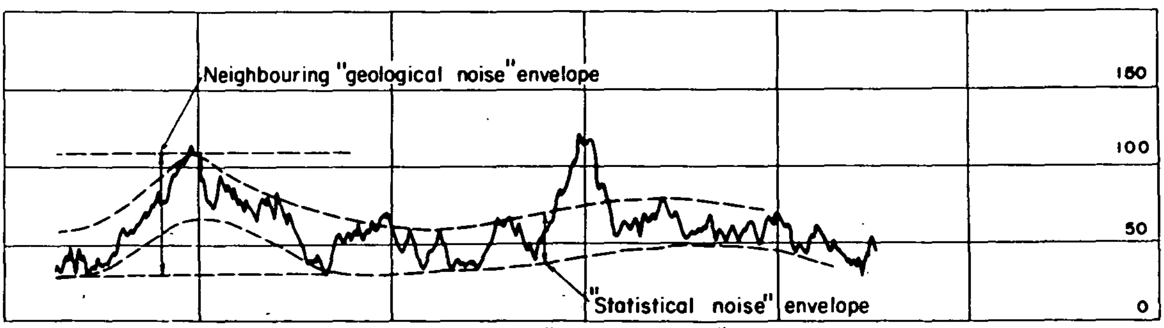
A Anomaly significant with respect to "geological noise" envelope.



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

TYPES OF RADIOMETRIC ANOMALIES

(After Young & Tipper, 1966)

(Based on H51/B1-74) To Accompany Record No 1970/2 H51/B1—74—3

APPENDIX 4

OPERATIONAL DETAILS

Staff provided by BMR

Party leader	:	R.A. Gerdes
Geophysicists	:	R.D. Beattie B.F. Cameron
Senior Radio Technician	:	J. Swords
Geophysical Assistants	:	K.A. Mort D. Park
Drafting Assistant	:	P. Moffat

Staff provided by Trans-Australia Airlines

Pilots	:	Captain L.T. Giddens Captain F. O'Grady First Officer J.R. Lindsay
Aircraft maintenance engineers	:	G.W. Ferguson B. Hall R. McNammee

Equipment

Aircraft	:	DC.3 (VH-MIN)
Magnetometers	:	MFS-5 saturable-core fluxgate, tail boom installation and coupled to Speedomax and digital recorders. MFD-4 Saturable core fluxgate magnetometer, ground installation storm monitor, output coupled to Esterline-Angus recorder.
Scintillometer	:	Twin-crystal MEL scintillation detector heads inboard. Single detector head outboard suspended by a cable 260 ft below 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, output to De Var recorder.

Survey specifications

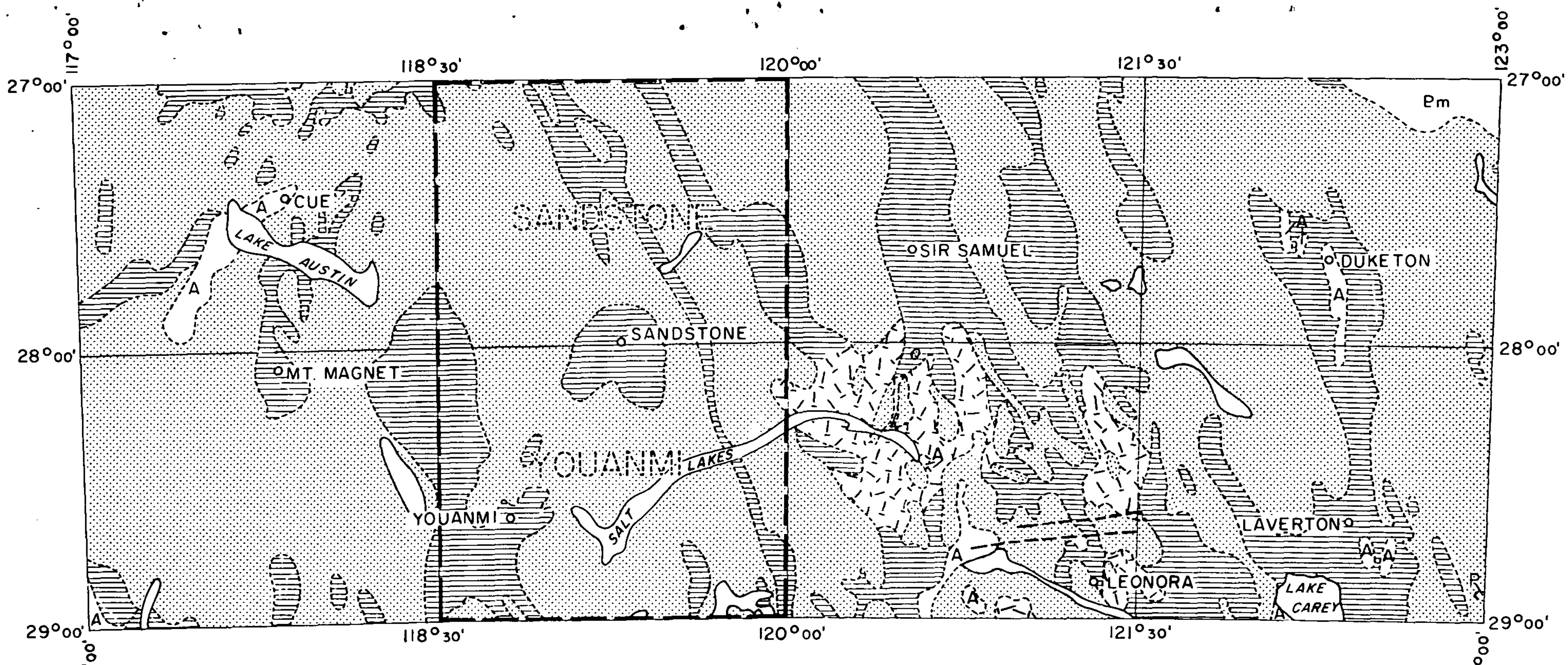
Altitude	:	500 feet above ground level.
Line orientation and spacing	:	East-west lines spaced 1 mile apart.
Tie system	:	North-south tie lines spaced 18 miles apart.
Navigation control	:	Aerial photographs

Recorder sensitivities

MFS-5	:	100 gammas per inch; large anomalies reflown at 200 gammas per inch.
MFD-4	:	20 gammas per inch.
Scintillometer	:	50 c.p.s. per cm
Radio altimeter	:	100 feet per cm

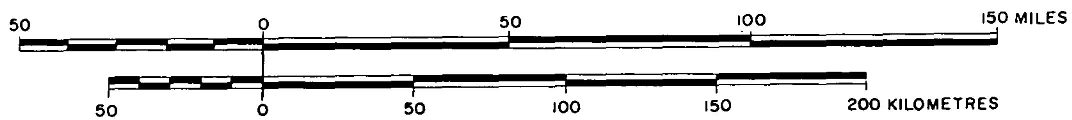
Scintillometer time constants

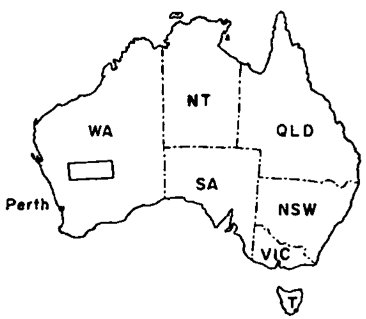
Inboard	:	10 seconds
Outboard	:	2 seconds with 'bird' raised (500' a.g.l.); 1 second with bird lowered (240' a.g.l.).



AIRBORNE SURVEY, SANDSTONE–YOUANMI, WA 1968

REGIONAL GEOLOGY





LEGEND

- - - - - - - - *Geological boundary*

— — *Survey area boundary*

P	*Permian sedimentary rocks*
Pm	*Middle Proterozoic sedimentary and volcanic rocks*
A	*Archaean sedimentary rocks*
/ /	*Basic dykes and sills of undetermined Precambrian age*
(horizontal ruling)	*Archaean sedimentary rocks, contains basic igneous rocks*
(stipple)	*Archaean granite*
(dashes)	*Zones of high grade metamorphism and zones of migmatite and gneiss*

GEOLOGY AFTER GEOLOGICAL SURVEY OF WESTERN AUSTRALIA, 1966

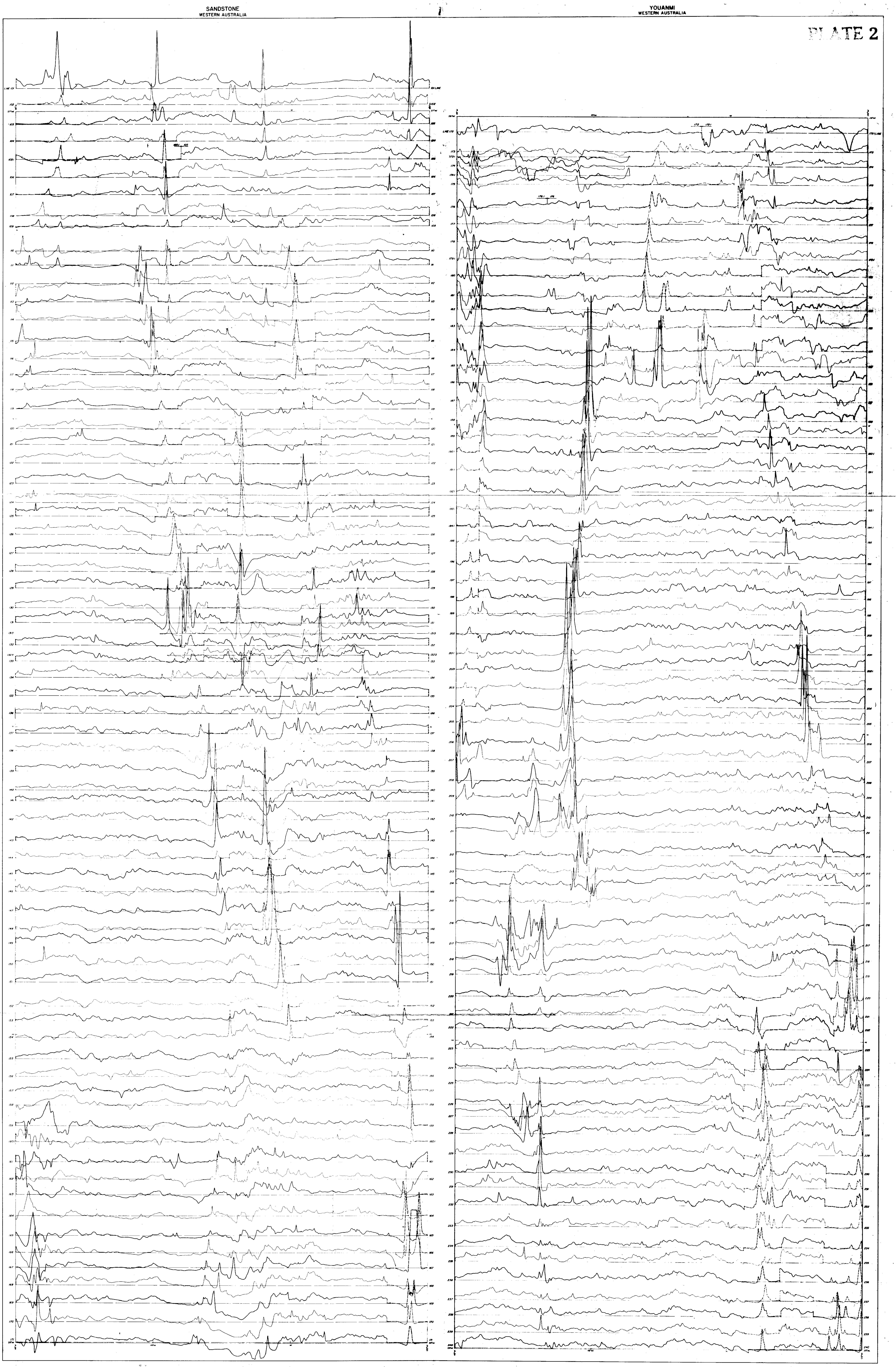
G50/B1-36

TO ACCOMPANY RECORD No. 1970/2

PLATE 2

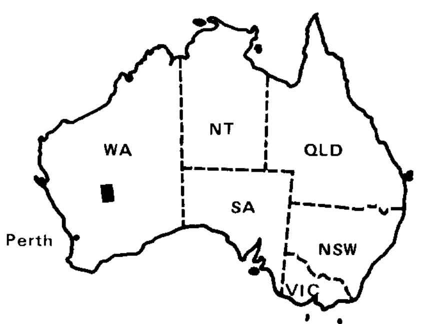
SANDSTONE
WESTERN AUSTRALIA

YOUANMI
WESTERN AUSTRALIA



AIRBORNE SURVEY, SANDSTONE–YOUANMI WA, 1968
TOTAL MAGNETIC INTENSITY PROFILES

LOCATION DIAGRAM

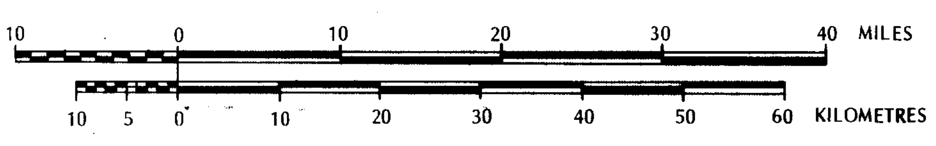


INDEX TO 1:250,000
MAP SERIES

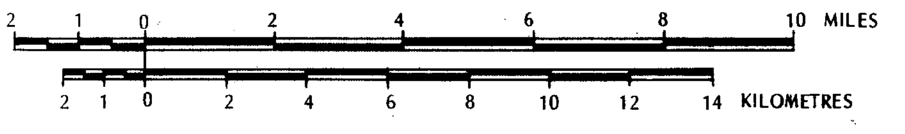
Belele	Glengarry	Wiluna
Cue	Sandstone	Sir Samuel
Kirkalocka	Youanmi	Leonora
Ninghan	Barlee	Menzies

(Based on G50/B1–41 and H50/B1–30)

EAST – WEST SCALE



NORTH – SOUTH SCALE



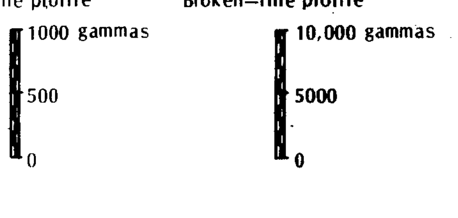
GEOPHYSICAL LEGEND

···· *No magnetic data available*

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 flight–lines are idealised and serve as baselines to the profiles. They approximate the actual flight path with a probable error of ± ¼ mile.
The profiles have been corrected for the south component of a regional gradient in total magnetic intensity. This component amounts to 8.0 gammas per mile.

APPROX. PROFILE SCALE

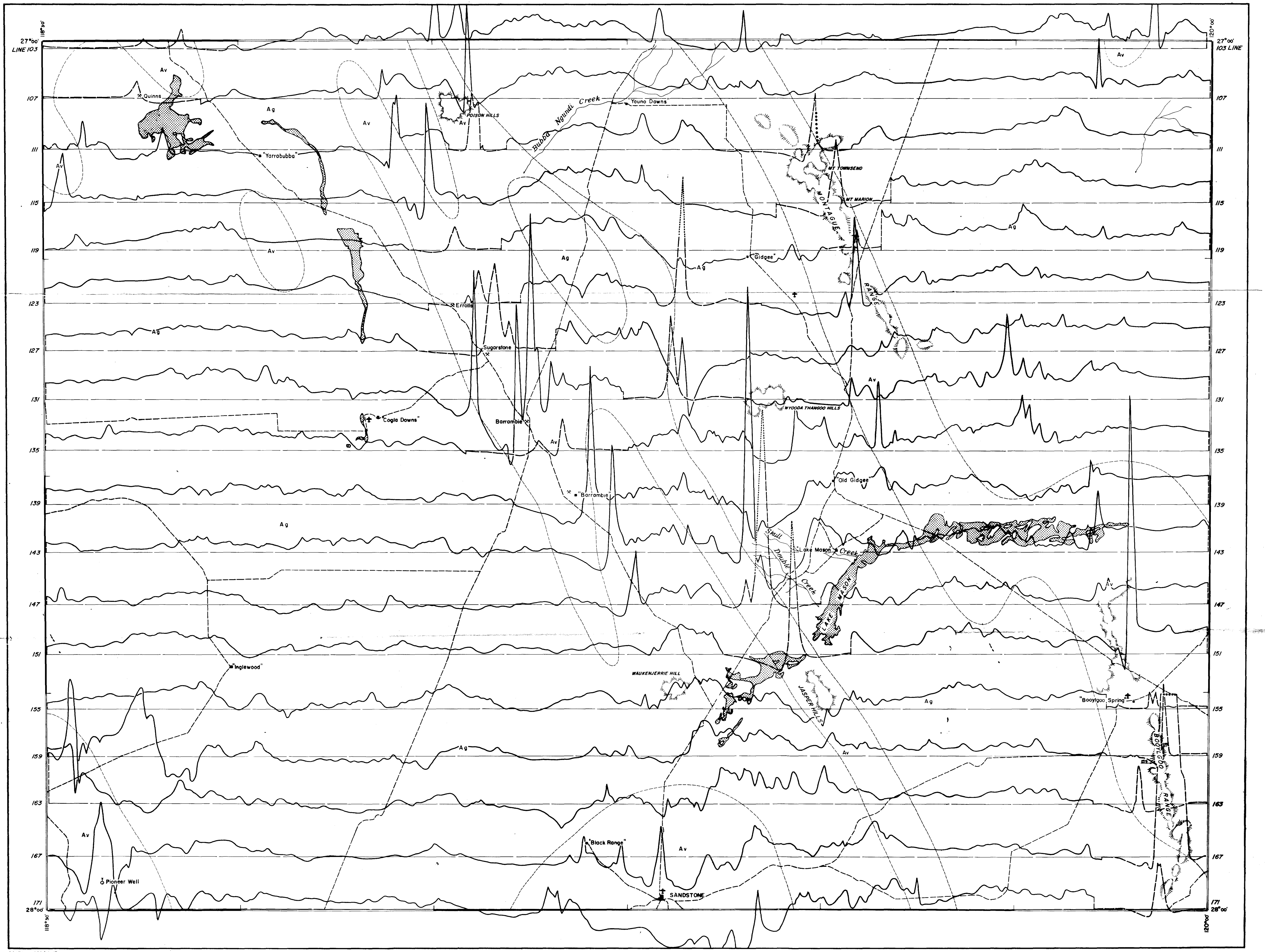


To Accompany Record No.1970/2 G50/B1–68

AUSTRALIA 1:250,000

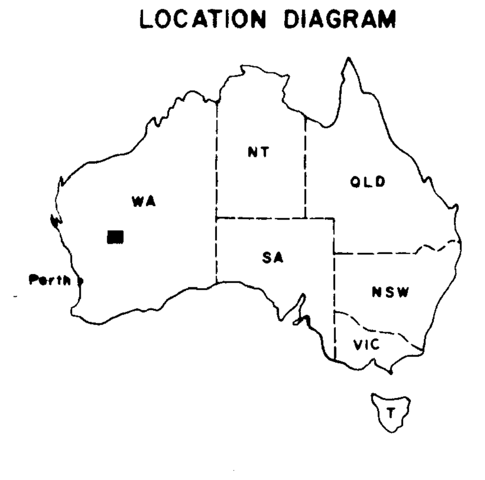
SANDSTONE
WESTERN AUSTRALIA

PLATE 3



BASED ON G50/B0-17
BASED ON G50/B0-18
BASED ON G50/B1-42

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

BELELE	GLENGARRY	WILUNA
CUE	SANDSTONE	SIR SAMUEL
KIRKALOCKA	YOUANMI	LEONORA

AIRBORNE SURVEY, SANDSTONE–YOUANMI, WA 1968

TOTAL MAGNETIC INTENSITY PROFILES
AND
GEOLOGY

4 0 4 8 12 16 20 MILES

5 0 5 10 15 20 25 30 KILOMETRES

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 FLIGHT-LINES ARE IDEALISED AND SERVE AS BASELINES TO THE PROFILES. THEY APPROXIMATE THE ACTUAL FLIGHT PATH WITH A PROBABLE ERROR OF ± 1/4 MILE.

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

THE PROFILES HAVE BEEN CORRECTED FOR THE SOUTH COMPONENT OF A REGIONAL GRADIENT IN TOTAL MAGNETIC INTENSITY. THIS COMPONENT AMOUNTS TO 8·0 GAMMAS PER MILE.

APPROX. PROFILE SCALES

Full-line profile	Broken-line profile
1000 gammas	10,000 gammas
500	5000
0	0

GEOPHYSICAL LEGEND

———	*500 gammas per inch profile*	- - - - - - - - - -	*Reconstructed profile*
— — —	*5000 gammas per inch profile*	•••••••	*No magnetic data available*

GEOLOGICAL LEGEND

AFTER GEOLOGICAL MAP OF WESTERN AUSTRALIA, 1966

- - - - - *Geological boundary*

ARCHAEAN
- Av — *Sedimentary rocks containing basic igneous rocks*
- Ag — *Granite*

TOPOGRAPHICAL LEGEND

— — —	*Road or track*		*River or creek*
■	*Homestead*	⚒	*Mining group*
	Hill feature	✈	*Landing ground*
	Lake		*Well*

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

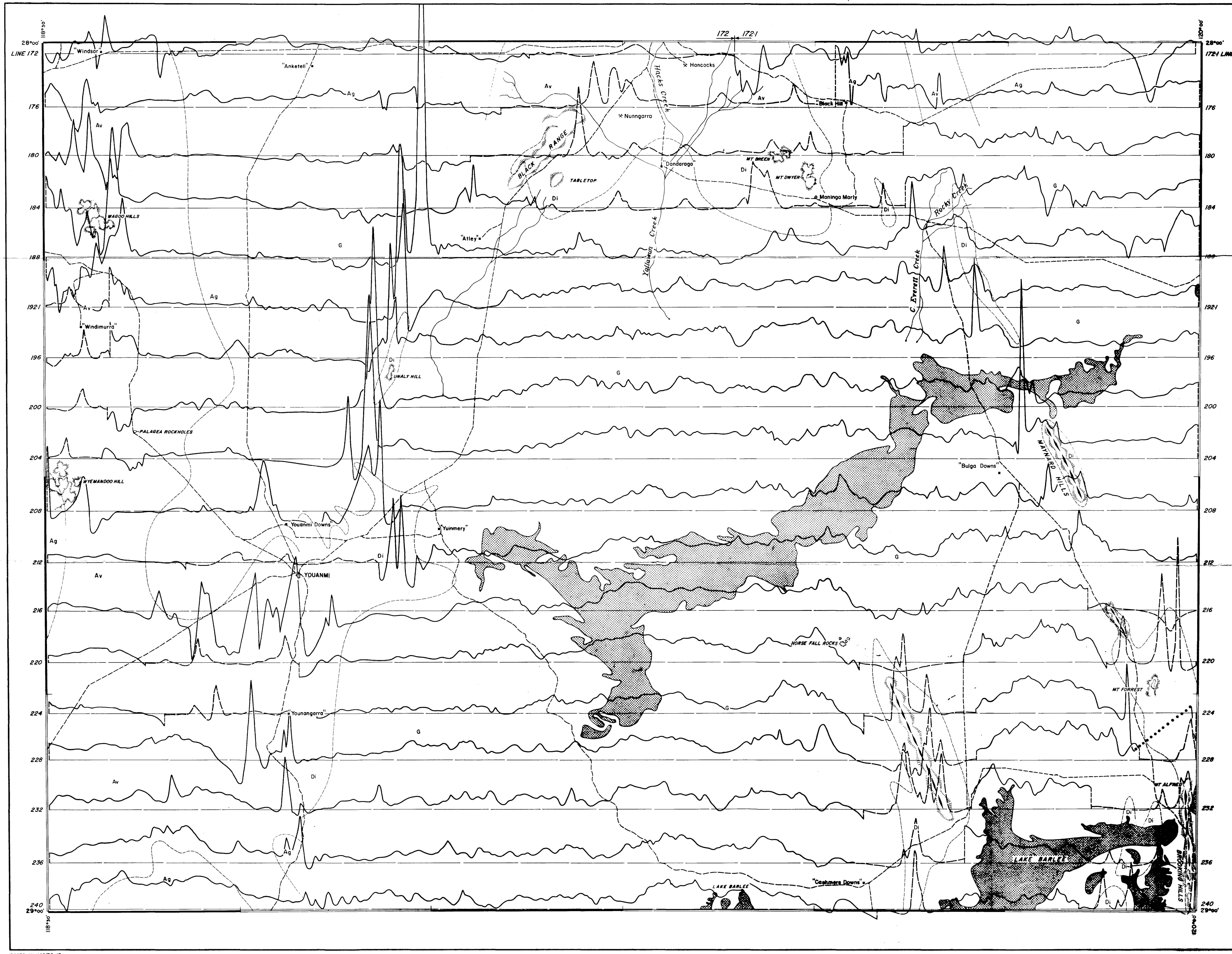
G50/B1-45

TO ACCOMPANY RECORD No. 1970/2

AUSTRALIA 1:250 000

YOUANMI

WESTERN AUSTRALIA



BASED ON H50/B0-17
BASED ON H50/B0-18
BASED ON H50/B1-31

GEOLOGICAL LEGEND

AFTER GEOLOGICAL MAP OF WESTERN AUSTRALIA, 1966

- ------ *Geological boundary*
- ARCHAEAN
  - Av — *Sedimentary rocks containing basic igneous rocks*
  - Ag — *Granite*

AFTER GEOLOGICAL SURVEY OF WESTERN AUSTRALIA BULLETIN 45

- ARCHAEAN
  - G — *Granite*
  - Di — *Greenstones (Epidiorites, Amphibolites and Metasediments)*
- *Ferruginous quartz schist*

GEOLOGICAL REFRENCE

A B

A. Geological Map of Western Australia, 1966
B. Geological Survey of Western Australia Bulletin 45

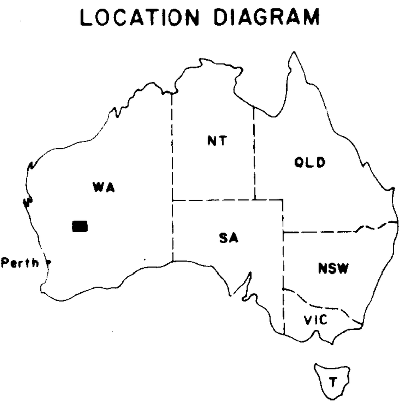
TOPOGRAPHICAL LEGEND

- *River or creek*
- *Road or track*
- *Homestead*
- *Hill feature*
- *Lake*
- *Mining group*
- *Rockholes*
- *Named place*
- *Rocks*

GEOPHYSICAL LEGEND

- ——— *500 gammas per inch profile*
- — — *5000 gammas per inch profile*
- •••• *No magnetic data available*

LOCATION DIAGRAM



AIRBORNE SURVEY, SANDSTONE–YOUANMI, WA 1968

TOTAL MAGNETIC INTENSITY PROFILES AND GEOLOGY

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

APPROX. PROFILE SCALES

Full-line profile: 1000 gammas, 500, 0
Broken-line profile: 10000 gammas, 5000, 0

INDEX TO ADJOINING SHEETS

CUE	SANDSTONE	SIR SAMUEL
KIRKALOCKA	YOUANMI	LEONORA
NINGHAN	BARLEE	MENZIES

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 FLIGHT-LINES ARE IDEALISED AND SERVE AS BASELINES TO THE PROFILES. THEY APPROXIMATE THE ACTUAL FLIGHT PATH WITH A PROBABLE ERROR OF ±¼ MILE.

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

THE PROFILES HAVE BEEN CORRECTED FOR THE SOUTH COMPONENT OF A REGIONAL GRADIENT IN TOTAL MAGNETIC INTENSITY. THIS COMPONENT AMOUNTS TO 8·0 GAMMAS PER MILE.

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

H50/B1-34

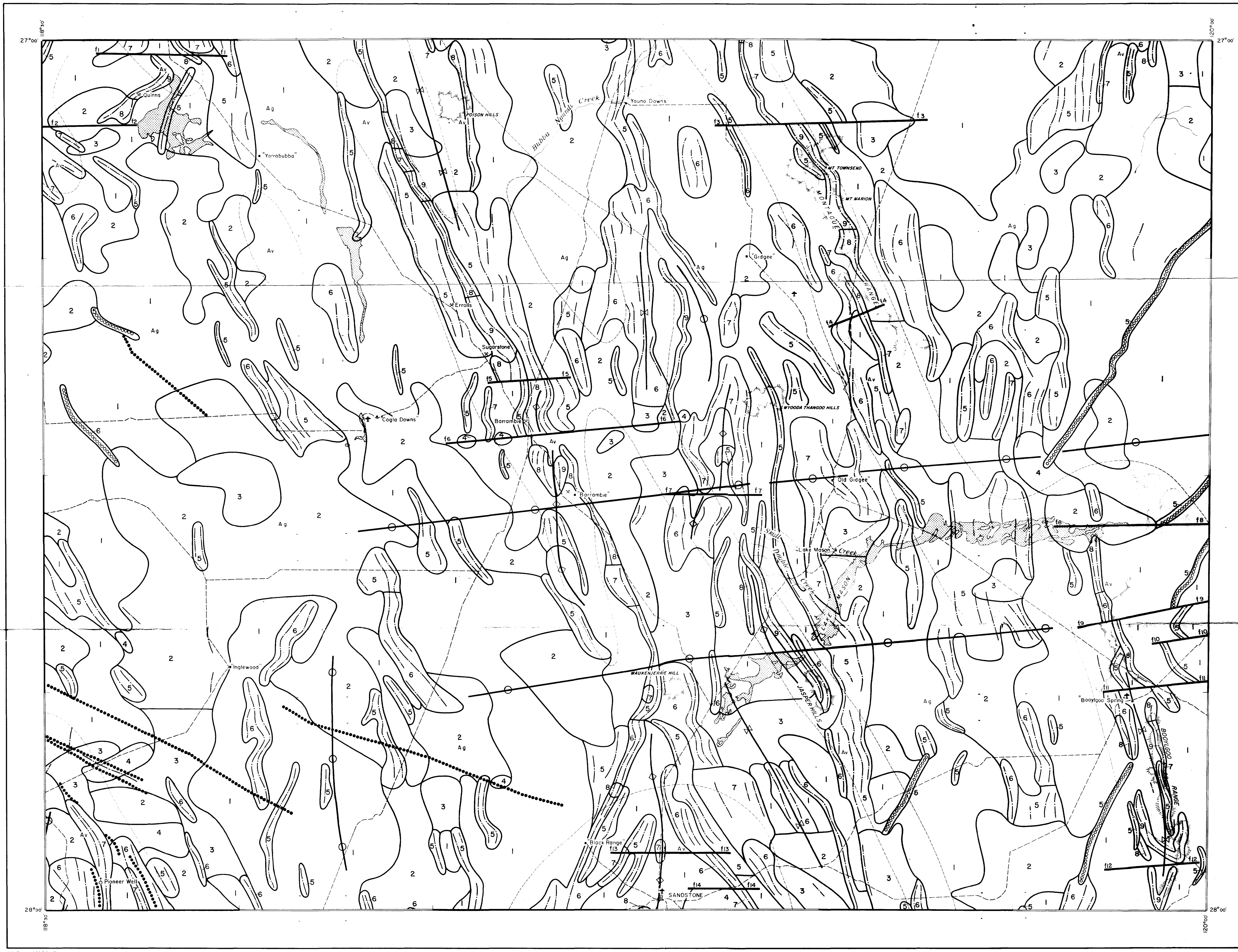
TO ACCOMPANY RECORD No. 1970/2

AUSTRALIA 1:250 000

SANDSTONE

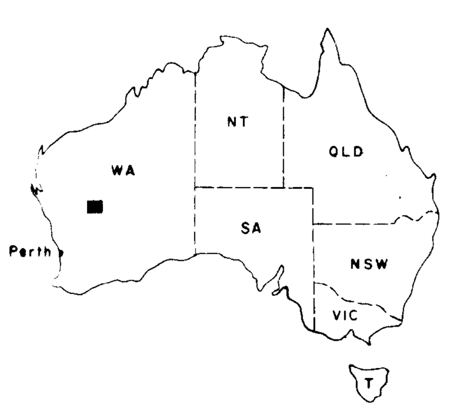
WESTERN AUSTRALIA

PLATE 5



BASED ON G50/B0-17
BASED ON G50/B0-18
BASED ON G50/B1-44

LOCATION DIAGRAM

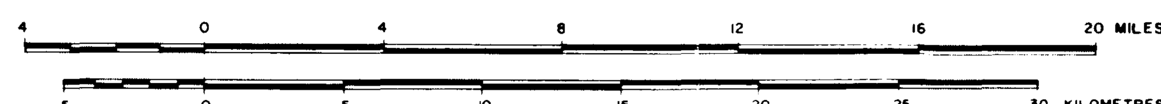


INDEX TO ADJOINING SHEETS

BELELE	GLENGARRY	WILUNA
CUE	SANDSTONE	SIR SAMUEL
KIRKALOCKA	YOUANMI	LEONORA

AIRBORNE SURVEY, SANDSTONE-YOUANMI, WA 1968

GEOPHYSICAL INTERPRETATION AND GEOLOGY



GEOPHYSICAL LEGEND

- Magnetic zone
- Magnetic trend
- Interpreted fault
- Fold axis
- Syncline, probable
- Anticline, probable
- Dyke, remanent magnetisation
- Dyke, induced magnetisation

GEOLOGICAL LEGEND

AFTER GEOLOGICAL MAP OF WESTERN AUSTRALIA, 1966

- Geological boundary

ARCHAEAN
- Av — Sedimentary rocks containing basic igneous rocks
- Ag — Granite

TOPOGRAPHICAL LEGEND

- Road or track
- River or creek
- Homestead
- Mining group
- Hill feature
- Landing ground
- Lake
- Well

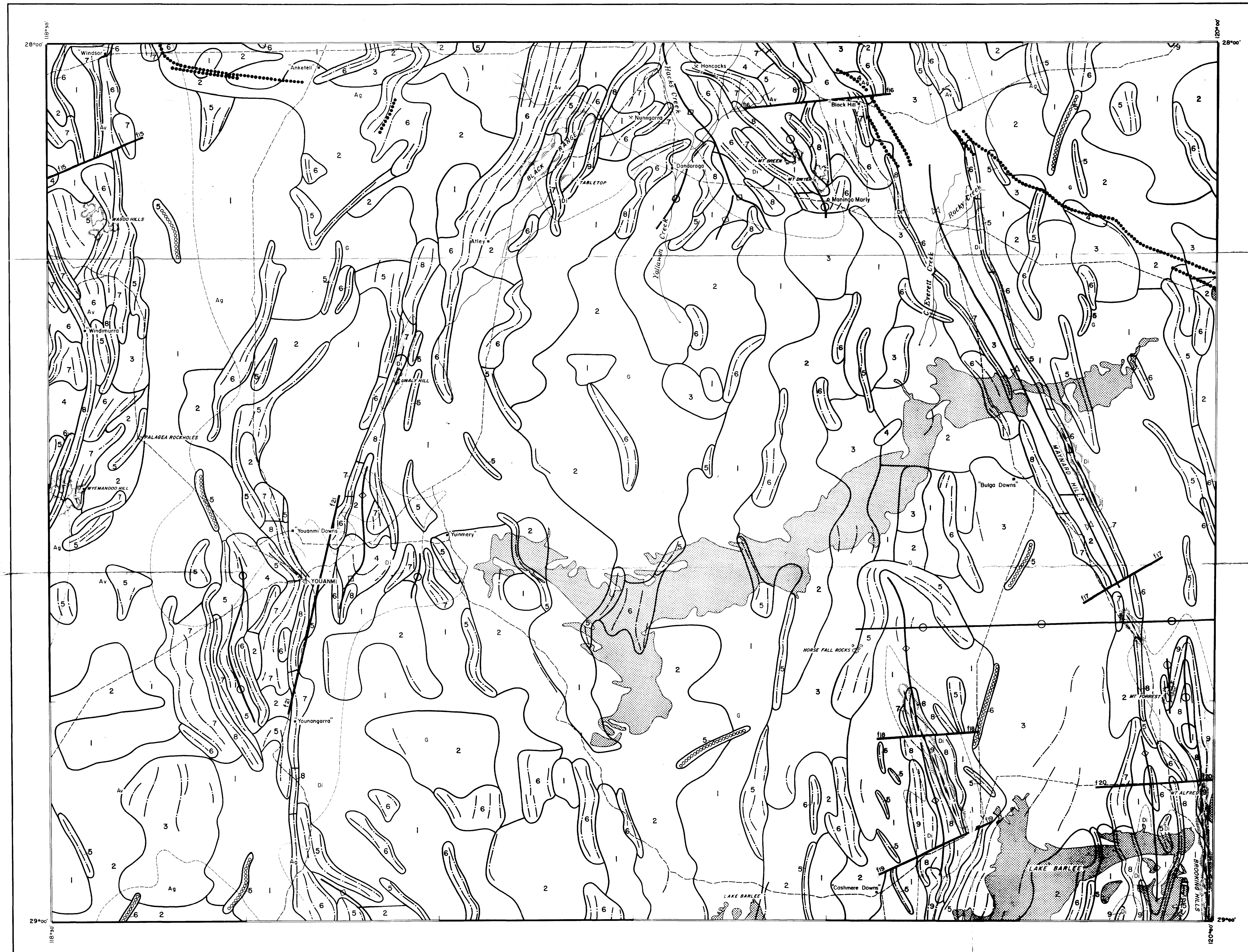
Geophysical Branch, Bureau of Mineral Resources, Geology & Geophysics.

G50/B1-47

TO ACCOMPANY RECORD No. 1970/2

AUSTRALIA 1:250 000

YOUANMI
WESTERN AUSTRALIA



BASED ON H50/B0-17
BASED ON H50/B0-18
BASED ON H50/B1-33

GEOLOGICAL LEGEND

AFTER GEOLOGICAL MAP OF WESTERN AUSTRALIA, 1966

Geological boundary

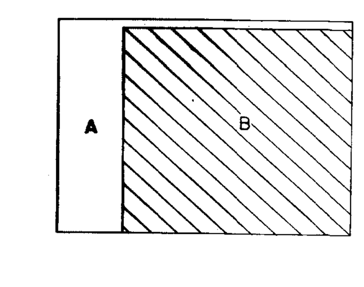
ARCHAEAN
- Av — *Sedimentary rocks containing basic igneous rocks*
- Ag — *Granite*

AFTER GEOLOGICAL SURVEY OF WESTERN AUSTRALIA BULLETIN 45

ARCHAEAN
- G — *Granite*
- Di — *Greenstones (Epidiorites, Amphibolites and Metasediments)*

Ferruginous quartz schist

GEOLOGICAL REFRENCE



A Geological Map of Western Australia, 1966
B Geological Survey of Western Australia Bulletin 45

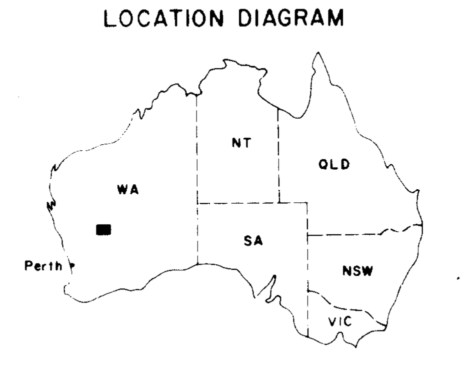
TOPOGRAPHICAL LEGEND

- *River or creek*
- *Road or track*
- *Homestead*
- *Hill feature*
- *Lake*
- *Mining group*
- *Rockholes*
- *Named place*
- *Rocks*

GEOPHYSICAL LEGEND

- *Magnetic zone*
- *Magnetic trend*
- *Interpreted fault*
- *Fold axis*
- *Syncline, probable*
- *Anticline, probable*
- *Dyke, remnant magnetisation*
- *Dyke, induced magnetisation*

LOCATION DIAGRAM



AIRBORNE SURVEY, SANDSTONE-YOUANMI, WA 1968

GEOPHYSICAL INTERPRETATION
AND
GEOLOGY

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

INDEX TO ADJOINING SHEETS

CUE	SANDSTONE	SIR SAMUEL
KIRKALOCKA	YOUANMI	LEONORA
NINGHAN	BARLEE	MENZIES

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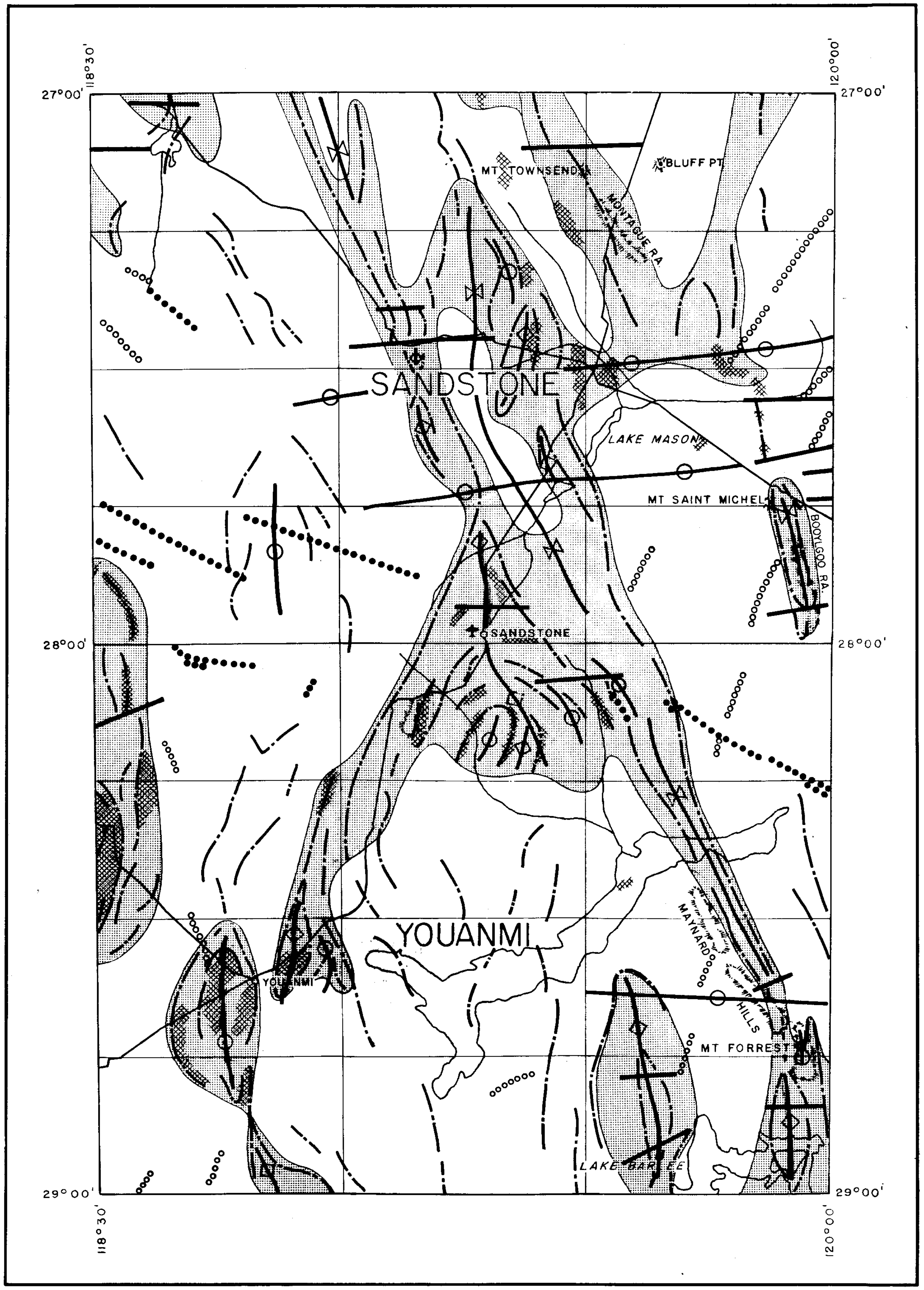
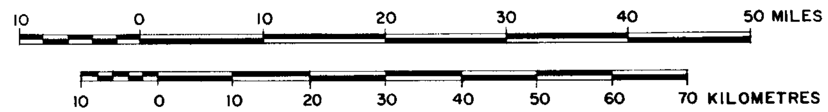
TO ACCOMPANY RECORD No. 1970/2

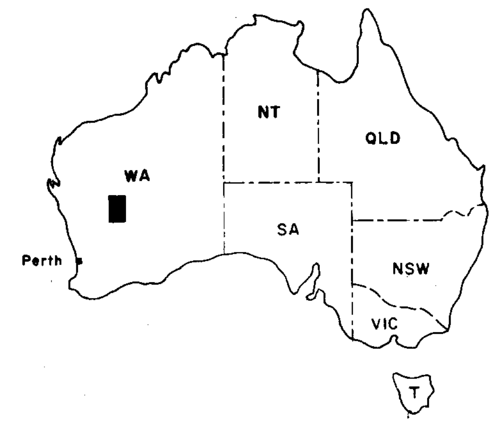


AIRBORNE SURVEY, SANDSTONE – YOUANMI, W A 1968

INTERPRETED REGIONAL GEOLOGY



LOCALITY DIAGRAM



GEOPHYSICAL LEGEND

- *Magnetic trend*
- *Fault*
- *Fold axis*
- *Syncline, probable*
- *Anticline, probable*
- *Basic and ultra basic rocks*
- *Greenstones*
- *Dyke, remanent magnetisation*
- *Dyke, induced magnetisation*

TOPOGRAPHICAL LEGEND

- *River or creek*
- *Road or track*
- *Hill feature*
- *Lake*
- *Named place*
- *Landing ground*

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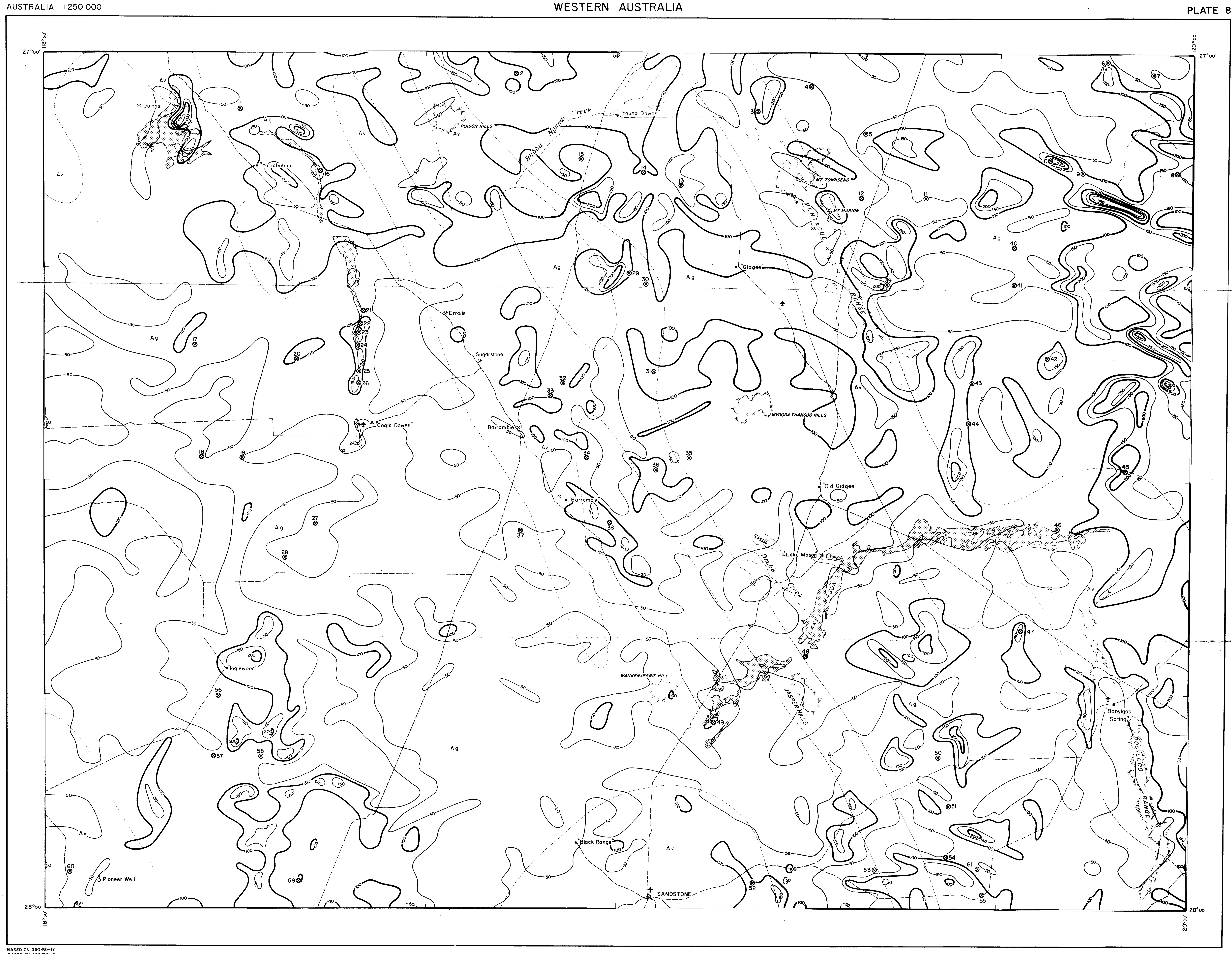
TO ACCOMPANY RECORD No. 1970/2

AUSTRALIA 1:250 000

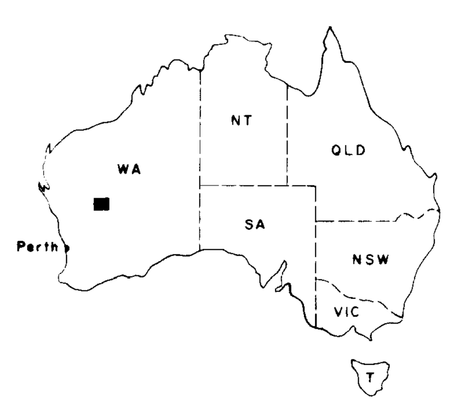
SANDSTONE
WESTERN AUSTRALIA

PLATE 8



BASED ON G50/80-17
BASED ON G50/80-18
BASED ON G50/81-43

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

BELELE	GLENGARRY	WILUNA
CUE	SANDSTONE	SIR SAMUEL
KIRKALOCKA	YOUANMI	LEONORA

AIRBORNE SURVEY, SANDSTONE-YOUANMI, WA 1968

RADIOMETRIC RESULTS
AND
GEOLOGY

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

GEOPHYSICAL LEGEND

—50— —100— *Radiometric contours, counts per second*

⊗16 *Radiometric anomaly, restricted source (Anomalies are numbered for reference only)*

GEOLOGICAL LEGEND

AFTER GEOLOGICAL MAP OF WESTERN AUSTRALIA 1966

Geological boundary

ARCHAEAN
- Av — *Sedimentary rocks containing basic igneous rocks*
- Ag — *Granite*

TOPOGRAPHICAL LEGEND

Road or track		River or creek	
Homestead		Mining group	
Hill feature		Landing ground	
Lake		Well	

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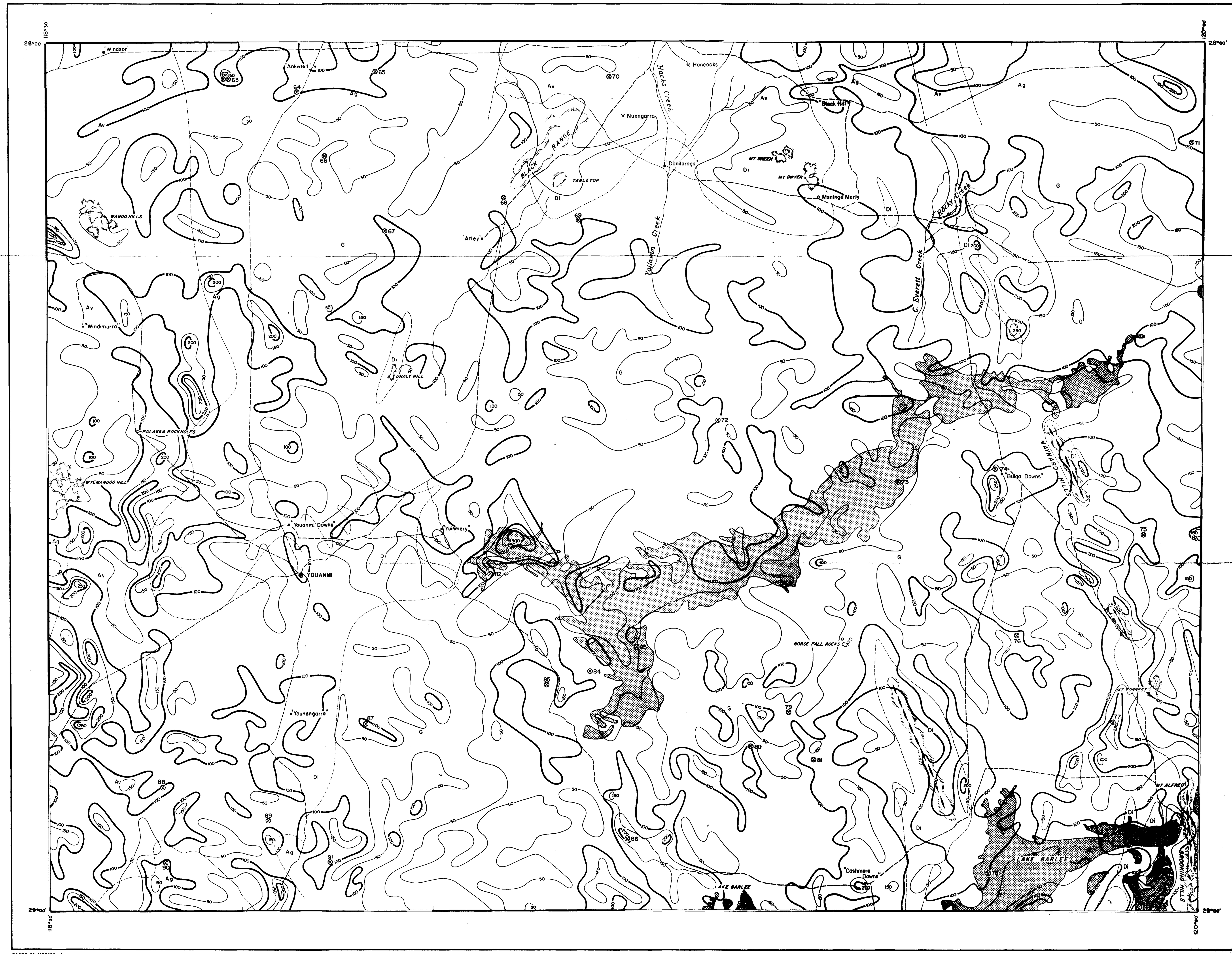
TO ACCOMPANY RECORD No. 1970/2

YOUANMI

WESTERN AUSTRALIA

AUSTRALIA 1:250 000



BASED ON H50/80-17
BASED ON H50/80-18
BASED ON H50/81-32

GEOLOGICAL LEGEND

AFTER GEOLOGICAL MAP OF WESTERN AUSTRALIA 1966

- - - - Geological boundary

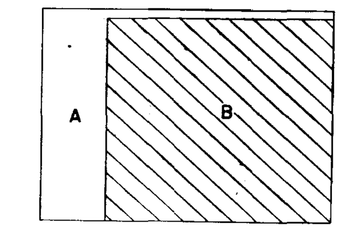
ARCHAEAN
- Av — *Sedimentary rocks containing basic igneous rocks*
- Ag — *Granite*

AFTER GEOLOGICAL SURVEY OF WESTERN AUSTRALIA BULLETIN 45

ARCHAEAN
- G — *Granite*
- Di — *Greenstones (Epidiorites, Amphibolites and Metasediments)*

Ferruginous quartz schist

GEOLOGICAL REFRENCE



A. Geological Map of Western Australia, 1966

B Geological Survey of Western Australia Bulletin 45

TOPOGRAPHICAL LEGEND

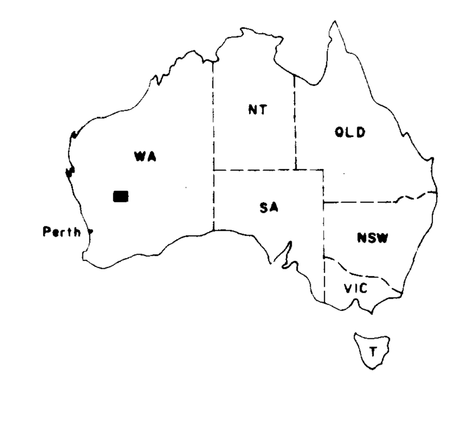
- *River or creek*
- *Road or track*
- *Homestead*
- *Hill feature*
- *Lake*
- *Mining group*
- *Rockholes*
- *Named place*
- *Rocks*

GEOPHYSICAL LEGEND

50 / 100 — *Radiometric contours, counts per second*

⊗16 — *Radiometric anomaly, restricted source (Anomalies are numbered for reference only)*

LOCATION DIAGRAM

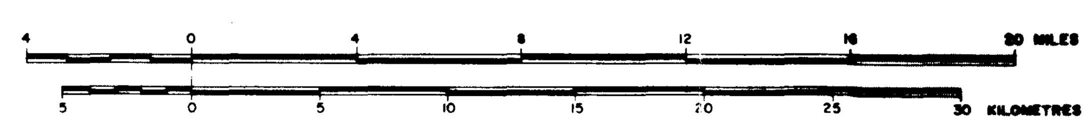


AIRBORNE SURVEY, SANDSTONE–YOUANMI, WA 1968

RADIOMETRIC RESULTS

AND

GEOLOGY



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CUE	SANDSTONE	SIR SAMUEL
KIRKALOCKA	YOUANMI	LEONORA
NINGHAN	BARLEE	MENZIES

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

H50/B1-35

TO ACCOMPANY RECORD No. 1970/2