COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



RECORD No. 1966/126



# ORROROO-PARACHILNA AIRBORNE MAGNETIC AND RADIOMETRIC SURVEY, SOUTH AUSTRALIA 1965

by

*D.B. TIPPER and W.A. FINNEY*

RECORD No. 1966/126

# ORROROO-PARACHILNA AIRBORNE MAGNETIC AND RADIOMETRIC SURVEY, SOUTH AUSTRALIA 1965

*by*

*D.B. TIPPER and W.A. FINNEY*

CONTENTS



ILLUSTRATIONS



Note. This Record supersedes Record No. 1965/229.

SUMMARY

An airborne magnetic and radiometric survey of part of the Flinders Ranges was flown during March and April 1965 in order to assist geological mapping, to determine the subsurface structure, and to detect structures associated with mineralisation.

The area surveyed has been divided into zones based on the dominant amplitude range of anomalies due to rocks at or near the surface. The observed correlation between many of these zones and the known surface geology will be useful in the completion of the geological mapping. Numerous zones of purely negative anomalies are of particular use in that all of them are attributed to one stratigraphic horizon.

In areas where the disturbance from surface sources is absent or rare, a deep magnetic basement was recognised underlying a thick geosynclinal sedimentary sequence. In the Parachilna 1:250,000 map area the basement is seen to deepen from the area boundaries to over 25,000 feet below mean sea level in the centre of this area. Deep troughs extend from this central region towards the north-west and south-west, the latter continuing in to the Orroroo map area. The increasing degree of magnetic disturbance towards the south-east of the survey area is tentatively attributed to either a regional metamorphic gradient, possibly associated with a subsurface igneous body, or to a regional increase in sedimentary iron due to a differing depositional environment.

A correlation was found between the magnetic pattern and known or suspected diapirs, structures associated with mineralisation in the area. As a result of this correlation, six localities are recommended as worthy of further ground investigation to test for diapiric activity.

A contour presentation of radiometric data shows that the general 'relief' of radioactive intensity is low. The highest values were obtained in the south-east of the area. Sixteen radiometric anomalies of restricted source areas were detected, of which ten are considered worthy of ground investigation.

## 1. INTRODUCTION

During March and April 1965 the Bureau of Mineral Resources, Geology and Geophysics, flew a magnetic and radiometric survey of the ORROROO and PARACHILNA 1:250,000 map areas, at the request of the Department of Mines, South Australia. The survey area of 12,600 square miles is bounded by latitudes 31°00' and 33°00'S, and longitudes 138°30'E and 139°30'E, and forms part of the central and southern Flinders Ranges.

Geologists from the Department of Mines have determined the regional geology of the Flinders Ranges and have mapped some areas in detail. The PARACHILNA and ORROROO areas were in the process of being mapped, and the geology shown in the plates was supplied by the Department of Mines. The purpose of the airborne survey was to assist this geological mapping, to detect structures associated with mineralisation, and to determine the regional sub-surface structure where possible.

The only previous geophysical investigations within the area were four gravity traverses and two ground magnetic traverses across the Blinman Dome diapir (Mumme, 1961), and an aeromagnetic traverse between Port Augusta and Broken Hill. Results across the Blinman Dome diapir showed an associated gravity 'low' and local, but not regional, magnetic 'highs'. The aeromagnetic traverse profile indicated a gradually rising field towards the centre of the area of the present survey.

Magnetic and radiometric surveys have been flown in adjacent 1:250,000 areas (Wells, 1962a & b; Young, 1963 & 1964, S.A. Mines Dept., 1952, 1957, 1959, & 1963). The results of these surveys, where relevant to the ORROROO-PARACHILNA survey, are discussed in sections 3 and 4.

Close co-operation with Department of Mines geologists (R. Dalgarno, P. Binks, and K. C. Mirams, pers. comm.) was maintained whilst writing the geological section of this report, and in the interpretation of the magnetic and radiometric data. The assistance of Department of Mines drafting staff during the survey is gratefully acknowledged.

## 2. GEOLOGY

### Regional geology

The survey area represents one part of a major geotectonic feature, the Adelaide Geosyncline (Plate 1). This is visible over a total distance of approximately 500 miles from the Fleurieu Peninsula in the south to the Peake and Denison Ranges in the north. The geosynclinal zone is partially bounded by older Precambrian shield areas: the Gawler Platform to the south-west, the Willyama Blocks to the east, and the Mount Painter Block to the north-east. These were positive areas during sedimentation in the geosyncline.

Continuous subsidence during Upper Proterozoic and Cambrian time allowed for a vigorous terrigenous sedimentation of shallow-water deposits, producing the extremely thick Adelaide System and Cambrian succession. Maximum thicknesses of sediments in the geosyncline are estimated at 60,000 feet of Upper Proterozoic age and 20,000 feet of Cambrian age. Within the survey area, these figures are reduced to maxima of 45,000 feet and 15,000 feet respectively (Dalgarno, pers. comm.).

An early Palaeozoic orogeny, beginning in the Middle Cambrian and culminating in the Ordovician period, folded and uplifted the geosynclinal sediments but was unaccompanied by marked igenous activity.

Metamorphism was restricted to areas adjacent to the basement shields and the localised syntectonic granites. The compressive forces folded the sediments into a mountain chain, which has since been planed down and partly buried beneath transgressive beds of Permian, Mesozoic, and Tertiary age. The present relief of the Flinders Ranges is entirely due to later tectonic stresses, mostly of upper Tertiary and Quaternary age, which caused broad doming and block-faulting.

Mineralisation is found associated with diapiric or piercement structures within the geosynclinal sediments.

## Stratigraphy

The outcropping and sub-surface rocks may be grouped into two major units, the 'Older Precambrian' basement, and the Upper Proterozoic-Cambrian geosynclinal sequence.

The 'Older Precambrian'. Although there are no outcrops of rocks pre-dating the Adelaide System in the survey area, the nature of the 'Older Precambrian' succession may be inferred with some confidence from the well-documented exposures in the adjacent areas of OLARY, PORT AUGUSTA, and COPLEY. Geological investigations in these areas (Miles, 1954; Thomson, 1964b; Campana and King, 1958; and Campana, 1958), show the 'Older Precambrian' basement to be an igneous and metamorphic complex, consisting mainly of :

| | | |
|---|---|---|
| Metasediments | : | Chiefly quartzites, schists, and gneisses with some ironstone formations and meta-dolomites. |
| Intrusive acidic rocks | : | Granites, granodiorites, aplites, and porphyries. |
| Intrusive and extrusive basic rocks | : | Include amphibolites, dolerites, and basalts. |

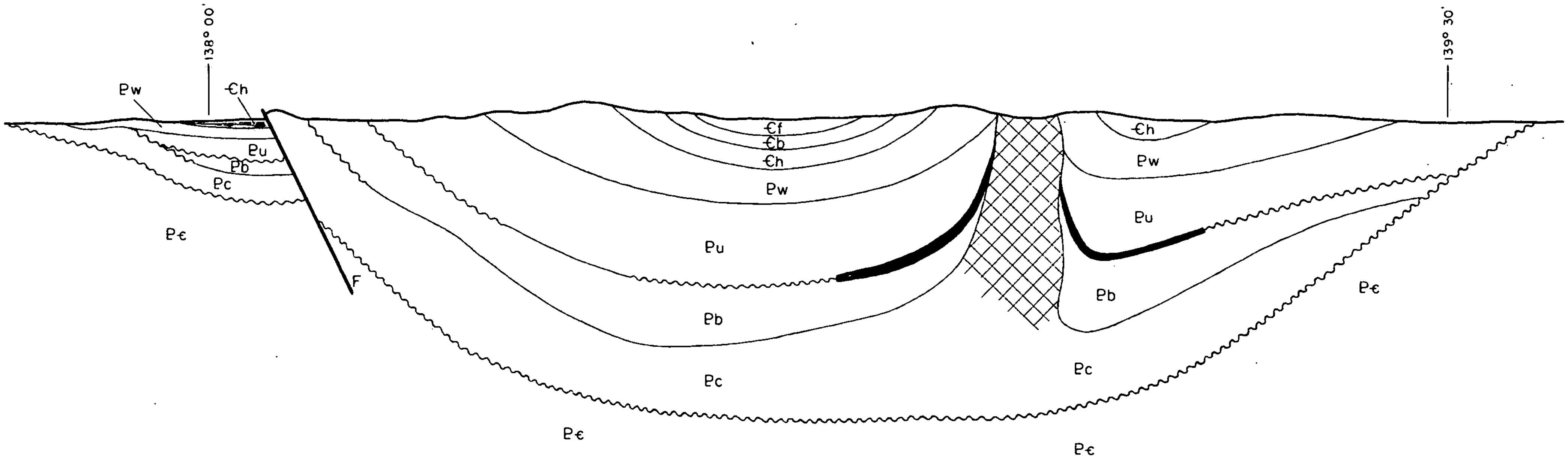
The Upper Proterozoic and Cambrian succession. The 'Older Precambrian' complex is overlain with angular unconformity by the Upper Proterozoic Adelaide System and Cambrian sequence. Rocks of both ages are discussed together as they form one continuous cycle of sedimentation.

The seven major rock units comprising this cycle are, in ascending order, the Callanna Beds, the Burra, Umberatana, and Wilpena Groups, the Hawker Group, Billy Creek Formation, and Lake Frome Group. The four lowest form the Adelaide System. The general relations of the units are illustrated in an idealised cross-section in Figure 1.

The Callanna Beds crop out in the extreme south-west of the ORROROO area and as small inliers in the north-west of the ORROROO area, consisting of calcareous and tuffaceous siltstones and limestones. Sandstones dominate in the southern exposures, attaining a thickness of at least 7000 feet. Elsewhere the Callanna Beds are only known in diapiric structures. The overall thickness of the buried sequence in the central and eastern parts of the area is believed to be of the order of 8000 feet. West of the Flinders Ranges, they thin to less than 1000 feet and may be entirely absent.

The Umberatana Group begins with the lower glacial unit (a succession of tillites, quartzites, and siltstones), which varies in thickness from about 1000 feet in the west, to over 10,000 feet in the east of the survey area. A haematite siltstone, the Holowilena Ironstone, is associated with the tillites and occurs in five of the major anticlinal cores in the

(To face page 2)




GEOLOGICAL LEGEND

| | |
|---|---|
| Ꞓf | *Lake Frome Group* |
| Ꞓb | *Billy creek Formation* |
| Ꞓh | *Hawker Group* |
| Ꝑw | *Wilpena Group* |
| Ꝑu | *Umberatana Group* |
| Ꝑb | *Burra Group* |
| Ꝑc | *Callanna Beds* |
| Ꝑ€ | *Older Precambrian* |
| | *Unconformity* |
| | *Diapiric structure* |
| F | *Fault* |
| | *Iron formation* |

FIG. 1

# IDEALISED W-E SECTION OF THE ADELAIDE GEOSYNCLINE

VERTICAL SCALE

0
10,000'
20,000'
30,000'
40,000'
50,000'

*Geology after R. Dalgarno, Department of Mines, South Australia (pers. comm.)*

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

H 54/B1 – 28

To Accompany Record No. 1966/126

east of the area. Above the lower glacial unit, a sequence of laminated shales has a total thickness of between 10,000 and 15,000 feet. The lowest beds of this interglacial sequence are a series of carbonaceous shales, pyritic and pyrrhotitic in part, named the Tindelpina Member. An upper glacial unit, developed only in the eastern part of the ORROROO area, has a lithology similar to that of the lower glacial unit. Elsewhere, its time-equivalent is a feldspathic sandstone sequence.

The Wilpena Group, a series of siltstones, sandstones, and shaly limestones, conformably overlies the Umberatana Group. Its thickness is normally of the order of 10,000 feet, of which the uppermost 3000 feet, the Pound Quartzite, crops out mainly in the PARACHILNA area. Red shales in the Wilpena Group on the western flank of the geosyncline intercalate with grey and green shales towards the east. The colour is stated by Thomson (1964a) to indicate the environmental conditions in which iron was deposited with the sediments.

The Cambrian succession has been fully described by Dalgarno (1964). The Lower Cambrian sequence, the Hawker Group, comprises mainly massive limestones and dolomites, which pass laterally into silty limestones and calcareous siltstones in less stable areas. The thickness of the Hawker Group varies from 2000 to 5000 feet, attaining a maximum in the north-east of the survey area.

Transitional between the Hawker and Lake Frome Groups, the Billy Creek Formation is a 2000-ft sequence of siltstones and sandstones. The formation is preserved in synclines in the northern part of the PARACHILNA area.

The Lake Frome Group represents the youngest beds of the Precambrian-Cambrian succession now preserved. It consists mainly of sandstones and has a thickness of 8700 feet.

With the exception of small dolerite outcrops within diapiric structures, there is no evidence in the survey area of igneous activity accompanying the Palaeozoic orogeny. To the east, however, in the OLARY area, the Anabama Granite has intruded sediments of the Umberatana Group, and is probably of early Palaeozoic age. The metamorphic effects of the intrusion on the Adelaide System are extremely variable. The presence of younger granite at moderate depth could explain the incipient metamorphism on the Manunda 1-mile sheet (Mirams 1961 & 1962).

Outcrops of Tertiary and Cainozoic rocks throughout the survey area provided a relatively thin cover of principally arenaceous sediments to the Upper Proterozoic-Cambrian sequence.

## Structure

The geological structure of the survey area is described in terms of folding, faulting, and diapiric structures.

Folding. The early Palaeozoic orogeny deformed the Adelaide geosynclinal sediments into two well-defined fold arcs, the Northern and South Central. The latter is sigmoidal in plan with northern convexity and southern concavity to the west (Dickinson & Sprigg, 1953). The survey area is situated where the fold axes of the southern arc swing from a northerly trend towards the east. Folding is simple but mdderately tight, especially in the anticlinal cores, whereas the synclines are relatively broad. There is only a local tendency to the development of isoclines. Individual fold axes are long and often change direction and pitch owing to numerous axial flexures. Major fold axes, as determined from surface geological mapping, are shown in the plates (Dalgarno and Binks, pers. comm.).

South of Hawker, on the western side of the area, the fold axes have a north to north-east trend, whilst to the east, they trend north-east to east. Throughout the ORROROO area, the fold axes have a gently undulating pitch as far north as Hawker, where a general axial plunge gives rise to a structural depression, exemplified by synclines trending north-east and containing Cambrian sediments. Folding in this area is open and regular. East of Hawker, a major anticline trends initially northwards before veering sharply to the east near Warcowie Homestead paralleling the arcuate regional trend.

In contrast, the northern half of the PARACHILNA area is characterised by sub-parallel north to north-west fold axes. Typical of this pattern is the north-north-west trending structural high in the vicinity of Blinman, which produces an elongate exposure of the Umberatana Group surrounded by the Wilpena Group. The two synclines complementary to this anticline contain approximately 12,000 feet of Cambrian sediments.

Faulting. Major overthrust faulting observed in the Flinders Ranges is confined in the survey area to the extreme western boundary. West of Quorn, a meridional fault having a throw of 15,000 feet has thrust Umberatana sediments against Cambrian rocks. The remaining faulting observed throughout the area is mainly of the oblique-slip form, although strike-slip forms are also common. The displacements along the fault planes range up to a few thousand feet. The strike of the faults is generally between north-north-east and east-north-east.

Diapiric structures. A notable feature of the Flinders Ranges is the frequent occurrence of bodies of breccia, usually localised in anticlinal cores or along major faults. Webb (1960) recognised that the elements of the breccias were similar in lithology to the Callanna Beds, and he concluded that they have been forcibly intruded from great depth, as piercement or diapiric structures, into a position outside their stratigraphic context. These diapirs are of considerable importance in that they are a major source of mineralisation in the area, and some are magnetically detectable. The structures are unusually large; the Blinman Dome diapir is 18 square miles and the Oraparinna and Worumba diapirs almost twice this area. Their formation is not fully understood. It is believed that the incompetent Callanna Beds acted in a decollement fashion under a pressure gradient and moved plastically into zones of weakness in the overlying succession. The thickness of the Callanna Beds is expected to reach a maximum at positions of diapiric activity.

The intruding sequence contains intensely deformed and brecciated rocks including dolomites, limestones, quartzites, siltstones, and some tuffaceous material. Gypsum, salt, and anhydrite, which produce diapirs in the Amadeus Basin, have not been recognised in the Flinders Ranges. In the Blinman Dome diapir, several large granitic blocks, similar to the older granite suite in the Mount Painter province, occur in the breccia, presumably torn from the basement. It is important with regard to magnetic interpretation that the bedded haematite siltstones occurring in the central-eastern part of the area commonly crop out adjacent to the core complex of the diapirs. Outcrops of basic igneous rocks also occur in the structures and have been described by Howard (1951), Mawson (1942), and Coats (1964). The basics fall into two age groups. Altered basalts and amygdaloidal lavas are found inter-bedded with the Callana Beds and were brought up with them during diapirism. Dolerite was intruded into the zones of weakness represented by the diapiric cores, apparently in late Proterozoic or early Cambrian time. This supports the concept of deep-seated fractures localising the diapirs. This concept is also suggested by the alignment of diapiric anticlines and faults.

The domal features may be interconnected at depth and, owing to repeated uplift of the growing diapirs during deposition of the Adelaide System, the sequence in the crestal areas of the domes is normally thinner than in the synclinal regions. Thus in many cases there is a drape effect off the flanks of the diapir, units adjacent to the contact being steep to overturned and flattening away from the structure. The only diapiric structure studied in detail is that of Blinman (Webb, 1961 & Coats, 1964). Other major diapirs known in the area are shown in Plates 4 and 5.

Mineralisation

A full account of the mineralisation in South Australia has been given by Thomson (1964a). Coats (1964) has described the mineralisation of the Blinman Dome diapir in detail and has examined other diapirs. A close relation was observed between mineral occurrences and diapiric structures. Mineralisation is associated with three specific rock types; the dolomite of the Blinman Dome diapir, the basalt interbedded with the Callanna Beds, and the late stage dolerites. The copper mineralisation of the first type is similar to that which tends to favour certain horizons in the Callanna Beds in the Willouran Hill and Mount Painter region, outside the survey area. The small copper occurrences associated with the interbedded volcanics of the Blinman Dome and other diapirs, are likewise parallel in the basaltic rocks of these sequences. Copper occurs as secondary minerals on joint planes and infilling amygdales. Primary sulphides occur in carbonate veins within or close to the basic rocks. A large range of minerals is associated with the dolerite intrusions of the Blinman Dome diapir. Recorded metals are copper, silver, lead, cobalt, nickel, and iron. Iron ore occurs with the dolerites in many areas. In one such body, Coats (1964) records that the mineral composition is chiefly martite with relics of magnetite. Iron prospects have been examined in the Blinman Dome and Worumba diapirs.

The bedded haematite siltstones within the Umberatana Group reach a maximum thickness of 400 feet but are apparently lenticular.

The laminated shales of the Tindelpina Member, overlying the lower glacial sequence of the Umberatana Group, often have disseminated pyrite, chalcopyrite, and minor pyrrhotite mineralisation. The sulphides tend to follow the laminations in carbonaceous shales.

## 3. MAGNETIC RESULTS AND INTERPRETATION

The magnetic data are displayed in Plates 2, 3, 4, and 5. Plates 2 and 3 show all profiles of total magnetic intensity reduced to an east-west scale of 1:250,000 and related to a series of east-west lines that approximate the flight paths. A north-south scale of 1:62,500 was used to improve data presentation. The profiles are accurately positioned with respect to longitudes near longitudes 138°22'E and 139°08'E; profiles recorded in the ORROROO area are further controlled near longitude 138°40'E. For the reduction of the original profiles by pantography, the aircraft's ground speed is considered constant along any one line in the PARACHILNA area, and along any one half-line in the ORROROO area. Departures from this constant speed introduce a positional error in the presentation of the magnetic data, which shows itself as a herring-bone pattern in the magnetic trends. The probable error is ± ½ mile, but larger errors of nearly one mile are recognised. This positional error is a function of distance from the control longitudes. Every fourth magnetic profile is shown in Plates 4 and 5, together with the most recent geological mapping.

The interpretation of the magnetic data is given in Plates 10 and 11.

ORROROO 1:250,000 map area

The magnetic profiles (Plate 2) show that the degree of magnetic disturbance varies considerably across the area. The easten half, especially in the south, is characterised by steep narrow anomalies of 50 to 1500 gammas amplitude. In contradistinction, the western and north-central regions are characterised by scattered low-amplitude anomalies superimposed on a flat or gradually varying magnetic field. As was found in the BURRA area to the south (Wells, 1962a), there are numerous negative anomalies wholly confined to the eastern half of the area.

Owing to the diverse nature of the magnetic field pattern, the ORROROO area has been divided into a series of zones characterised by anomalies in the area. Trends and zones are shown in Plate 10. Listed below are the zones and their magnetic character :

| Zone type | Magnetic character |
|---|---|
| 1 | Positive anomalies mainly less than 25 gammas |
| 2 | Positive anomalies mainly in the range 25 to 100 gammas |
| 3 | Positive anomalies mainly in the range 100 to 200 gammas |
| 4 | Positive anomalies mainly in the range 200 to 600 gammas |
| 5 | Positive anomalies mainly greater than 600 gammas |
| 6 | Negative anomalies |

Geological significance of zones. A zone of type 1 covers most of the ORROROO area and is characterised by scattered sharp anomalies of low-amplitude. These anomalies are superimposed on a gradually changing magnetic field. Thus two magnetic horizons are evident; one, discontinuous and at surface level, and the other at great depth. It is deduced that a very thick sequence of basically unmetamorphosed, non-magnetic sediments overlies a deep heterogeneous basement. This is consistent with current geological concepts, namely a thick, unmetamorphosed Upper Proterozoic succession overlying a metamorphosed older Precambrian basement. Many of the low-amplitude anomalies may be correlated with outcrops of the Tindelpina Member and the lower glacial unit, both of which are known to contain iron. (The Tindelpina Member is not shown in the plates but it immediately overlies the lower glacial unit). As much of this low-order disturbance is irregularly distributed and of similar amplitude, it is impossible to resolve many trend lines, especially where Cainozoic cover diminishes geological control.

The intrazonal boundary near Belton in the north-centre of the ORROROO area enclosed a region of local magnetic disturbance of less than 25 gammas amplitude. This region is situated on the axis of a major anticline and possibly reflects a hitherto unknown diapir, blanketed by Cainozoic alluvium. The similar area to the east is near a region of suspected diapirism (Binks, pers. comm.).

The low order of magnetic disturbance from surface rocks, in zones of type 1, does not mask the effect of the deeper magnetic basement. From the large, broad anomaly in the north-west quadrant of the ORROROO area, depth determinations have been obtained using the half-maximum-slope technique of Peters (1949) with a Peters' factor of 1.6. The shape of the anomaly is not ideal for accurate treatment, but values of 25,000 to 30,000 feet below mean sea level are of the correct order. A qualitative analysis of the profiles, together with scattered depth determinations shows that the Adelaide System is extremely thick throughout the western half of the area, and that there is a gradual rise in basement towards the south. An anomaly on line 126 two miles north of Melrose (Plate 2) is due to a magnetic body approximately 5000 feet wide, the top of which is approximately 1000 feet above sea level. The magnetic susceptibility, of about $0.4 \times 10^{-3}$ c.g.s. units is similar to that of gabbro. Basic rocks have already been recognised in this vicinity. This body is not a part of the older Precambrian basement. Again by qualitative and quantitative analyses of the magnetic profiles, the deeper basement is seen to rise to the north-east. Sufficient depth determinations have been obtained in this region to enable contouring of the magnetic basement topography (Plate 10).

Five zones of type 1, surrounded by zones of higher order, are shown in the south-east quadrant of the area. In the south of the largest zone, the zonal boundary closely follows the Umberatana/Wilpena Group contact. The westward extension of this zone between latitudes 32°45'S and 32°50'S, where geological mapping is incomplete, almost certainly defines the extent of the Umberatana Group.

Zones of type 2 are generally small and isolated. Almost all coincide with areas of Cainozoic alluvium overlying rocks of probably Umberatana age. Although they are probably due to slight local increases of iron content in the Umberatana Group, the possibility of diapiric structures should not be discounted.

Zones of type 3 are confined to the eastern half of the area and, in general, enclose quite strong magnetic trends. In the south-east quadrant, most of the zones may be correlated with the lower beds of the Wilpena Group. Two facts have been observed and require explanation. Firstly, the outcropping Wilpena Group in the western and north-central parts of the area has no magnetic expression. One possible explanation for the increase in magnetic disturbance towards the south-east is a regional metamorphic gradient, perhaps the result of a subsurface igneous body of similar age to the Anabama Granite, which crops out on the adjacent Manunda 1-mile sheet. However, it is known that the colour of the Wilpena Group shales changes from red in the west to green in the east, reflecting changes in the environment in which iron was deposited with the sediments. It is possible that larger quantities of ferromagnetic mineral were syngenetically deposited in the south-east of the area. The second observation is that zones of type 3 in the south-west quadrant of the ORROROO area favour those beds of the Wilpena Group which have an easterly component of dip, and an element of remanent magnetisation is suggested.

The zone of type 3, approximately 4 miles west of Nantabibbie, encloses an area of suspected diapirism (Mirams, pers. comm.). If a diapiric origin is confirmed at this locality, it may be inferred with some confidence that the diapir extends the full length of the zone, as the magnetic trends are continuous.

The geological significance of the two zones of type 3, situated in the Burra Group south and south-east of Meadow Downs Homestead, is not fully known. The larger zone lies between two major faults, but the rock causing the anomalies of this zone cannot be determined without ground investigation.

The large zone of type 3 in the north-east quadrant of the ORROROO area appears to have no stratigraphic correlation. The zone is adjacent to a major anticlinal axis, and a possible explanation is local metamorphism from a buried igneous body, of similar age to those cropping out in the adjacent 1-mile areas of Plumbago and Winninnie, east of the survey boundary. There is a noticeable lack of magnetic trends in this region, suggesting a small angle between geological strike and flight-line orientation.

The five zones of type 4 are confined to the eastern half of the area, and of these, four are situated in the south-east quadrant. The more westerly zone trends northwards and coincides with an outcrop of the Wilpena Group which forms the western limb of a major syncline. The amplitude of this zone reaches 500 gammas. The widening of the zone in the north, centred 12 miles west-south-west of McCoys Well, encloses even larger anomalies with a maximum amplitude of 650 gammas. An analysis of these anomalies indicates that they reflect a magnetic body nearly 800 feet wide at a depth of approximately 700 feet below the surface. The magnetic susceptibility contrast ofthis body, relative to the adjacent sediments, is consistent with that of a basic intrusion or moderately metamorphosed rock mass, fairly high in iron content.

The U-shaped zone of type 4, south of McCoys Well, is mainly correlated with outcropping Wilpena sediments. However, approximately 4 miles west of Paratoo, a large anomaly of 300 gammas, seen on lines 117, 118, and 119, was detected over an area of suspected diapirism, where basic rocks have been recognised. The anomaly is complex, being the partial resolution of more than one source, and this is consistent with the geological complexity observed in a typical diapir.

A third zone of type 4 occupies the extreme south-eastern corner of the ORROROO area and adjoins similar magnetic disturbance in the Manunda 1-mile area to the east. At least part of the zone is attributed to the ironstone beds in the lower glacial unit of the Umberatana Group, known to crop out in this zone. Some of the disturbance is probably due to the Tindelpina Member underlying the Cainozoic cover.

The fourth zone of type 4 is seen in the north-eastern quadrant of the ORROROO area. The disturbed nature of the magnetic pattern signifies a variety of rock-type, and the lack of observable anomaly-continuity is indicative of a geological strike approaching east-west. The possibility that a sub-surface igneous body is the cause of this zone, as already suggested, would explain the increased magnetic disturbance.

Four relatively small zones of type 5 are located in the north-east quadrant of the area. The most westerly zone is situated adjacent to a suspected diapir (Dalgarno, pers. comm.). The amplitude of the anomaly in this zone reaches 1000 gammas, suggesting an outcrop of the Holowilena Ironstone. This in no way detracts from the possibility of a diapiric structure, as it is known that this ironstone often lines the perimeter of diapiric cores. The southern two zones of type 5 are directly correlatable with outcrops of the Holowilena Ironstone, and the magnetic trends faithfully follow the geological strike. The more easterly of these zones has an anomaly amplitude of 200 gammas, indicative of a very high iron content, and is similar to anomalies from the same formation detected in the OLARY area. A similar zone is seen in the extreme north-east corner of the area.

Without exception, all zones of type 6 are correlated with the Tindelpina Member of the Umberatana Group, and thus serve as an excellent marker horizon for geological mapping. The configuration of these negative zones is extremely interesting. Of those which are coincident with mapped outcrops, almost all occur on either the western limb of a syncline or the eastern limb of an anticline; i.e. negative disturbance is almost wholly confined to those beds of the Tindelpina Member that have a component of dip in an easterly direction. It would also appear that there is a tendency for the negative anomalies to favour north-pitching folds. It is also noted that at certain fold structures, where the Tindelpina Member produced a negative anomaly on the easterly dipping flank, a positive anomaly was produced by the same formation on the corresponding westerly dipping flank. The clearest example of this is in the area east of Meadow Downs Homestead, where a synclinal axis and a parallel anticlinal axis strike approximately north-east. Two zones of type 6 coincide with outcrops of the Tindelpina Member that dip south-easterly, whereas a zone of type 4 is produced by this formation where it dips to the north-west. A similar correlation is seen along the anticline north-west of Peterborough. There are only three zones of type 6 that are correlated with the Tindelpina Member having a component of dip in a westerly direction. The first, south-south-east of Yalpara in the centre of the area, occurs where the beds dip at a very small angle (Binks, pers. comm.); the second, immediately east of Nantabibbie and Nackara, is of greatly reduced amplitude; the third, five miles west of Minburra Homestead, occurs on a southerly plunging anticline.

The magnetic data obtained in the BURRA area have now been contoured and the geology has been mapped. A similar correlation is observed between the negative disturbance and the Tindelpina Member. It is therefore postulated that these pyrrhotitic shales were remanently magnetised prior to folding, such that the polarity of the present magnetic field from the shales is a function of geological dip. The negative disturbance is confined to the eastern half of the area, and cannot be used to determine the geology of the western half, beneath the Cainozoic cover.

The presence of remanent magnetisation has hampered the attempt to resolve fold structures from zonal and trend-line features. It can be seen, however, that the magnetic data in no way conflict with the mapped geology.

A detailed ground investigation of four areas is recommended to test for diapiric structures. These areas are shown shaded in Plate 10.

## PARACHILNA 1:250,000 map area

The magnetic pattern in this area is very similar to that in the western half of the ORROROO area, being one of broad anomalies, several hundred gammas in amplitude, on which are superimposed groups of steep, narrow anomalies generally of low amplitude. The former are due to a deep magnetic basement and the latter to sources at, or near, the surface.

The primary objective in the interpretation of the broad anomalies was the resolution of magnetic basement topography. Determinations of depth to magnetic basement were made where possible and the results are presented as a contour map (Plate 11). All values were obtained using Peters' half-maximum-slope technique and a Peters' factor of 1.6. It is emphasised that owing to the paucity of reliable depth determinations, the contour map should be regarded as only a general representation of the magnetic basement topography. For this reason, a large contour interval of 5000 feet was chosen in contouring the greater part of the area. In the north-eastern and south-eastern regions, where greater control was obtained, the contour interval was reduced to 2000 and 1000 feet respectively. Where only approximate depth estimates were obtainable, contours are shown in dashed form. Individual determinations shown in Plate 11 are considered reliable to ± 15%.

The magnetic basement in the greater part of the area is deeper than 15,000 feet below mean sea level (M.S.L.). A depression in the magnetic basement, deepening to more than 25,000 feet below M.S.L., occupies the centre of the area. The contour map shows that a deep trough, more than 20,000 feet below M.S.L., extends from the centre to the north-west corner of the area. A qualitative analysis of the magnetic profiles suggests that the central depression also extends to the south-west region of the area, but the lack of reliable depth determinations renders contouring impracticable. To the west, the basement rises gently, and at the western boundary of the area it is less than 15,000 feet below M.S.L. There is a general disparity between basement contour values for the western part of the PARACHILNA area and those drawn for the eastern part of the TORRENS area (Young, 1964). An analysis of the profiles for the two areas strongly suggests that the contour patterns relate to two different magnetic horizons.

Between latitudes 31°12' and 31°17' approximately, an elongated basement 'high', trending 5° north of east, extends 15 miles from the western boundary of the area. The basement appears to rise sharply to less than 10,000 feet below sea-level. The amplitudes of the anomalies suggest that the 'high' is associated with a change in basement lithology as well as a change of depth. It is postulated that a rock-mass of low magnetic susceptibility, relative to the surrounding basement, has been either intruded at depth or block-faulted into a higher position. An alternative explanation for the shallow depth determinations is that they relate to a higher magnetic horizon in this region, and possibly that which was contoured in the TORRENS area.

On the eastern side of the PARACHILNA area, the magnetic basement rises with gentle gradient to less than 15,000 feet below M.S.L. In the northern region, the depth is less than 5000 feet and the gradient towards the centre of the area appears to be fairly constant. The contour configuration in the north-eastern and south-eastern regions is more complex and reflects sharp rises in basement level. Because of Cainozoic cover, the basement ridge in the north-eastern region cannot be correlated with surface geology. In the south-eastern region, however, the rise in basement may be correlated with the Bibliando Dome. The basement, as indicated by the contours, is domal in shape, with steepest gradient to the north. This northerly gradient extends over a broad front and is coincident with the northern flank of a major anticline. The trend of the basement 'high' parallels the anticlinal axis.

Anomalies have been zoned on the same basis as was used in the ORROROO area. All anomalies are contained in zones of type 1 to 4, the maximum amplitude being 250 gammas. Many of these zones are attributed to known diapiric structures, the anomalies probably reflecting the basalts and dolerites known to crop out within these structures.

The Blinman Dome diapir is clearly reflected by the magnetic profiles, and it is seen in Plate 11 as a zone of type 2. Magnetic disturbance occurs on four profiles with a maximum extent of five miles. It is not possible to trace individual anomalies from line to line and, in general, the irregular appearance of the magnetic disturbance is in agreement with the geological character of the diapiric structures.

Approximately 14 miles east of Blinman, the Wirrealpa diapir is marked by two zones of type 1 and type 3 and 7 miles north of Wirrealpa Homestead, another zone of type 3 encloses a mapped diapiric outcrop.

About 5 miles north-east of the Wirrealpa Homestead, a zone of type 2 is located in an area mapped as Cainozoic alluvium. The magnetic disturbance in this zone is very similar in character to that obtained over neighbouring diapirs, and the region is considered to be of probable diapiric origin.

The anomalies associated with diapiric structures are generally small and irregular but some are of relatively large amplitude, up to 250 gammas. This latter form is usually evident near a zonal boundary and is probably the magnetic expression of ironstone beds known to occur near the perimeter of some diapirs. This correlation is particularly noticeable in the case of the Oraparinna diapir. Two zones of type 2 are located 16 miles south-east and 25 miles west of the Oraparinna Homestead. The former can be correlated directly with a mapped diapiric outcrop but the latter occurs in an area covered in a blanket of alluvium. It is suggested that basic rocks near the surface, possibly within a diapiric structure, are the source of this disturbance.

In the south of the area, a zone of type 2 occurs in the vicinity of the Worumba diapir. The zone has a similar north-south extent as the diapir, but is displaced slightly to the west. This may be due in part to the positional error of the magnetic data on the preliminary flight-line plot. However, the fact that the displacement is consistently to the west suggests that the Worumba diapir extends westwards from the mapped outcrop beneath Cainozoic cover.

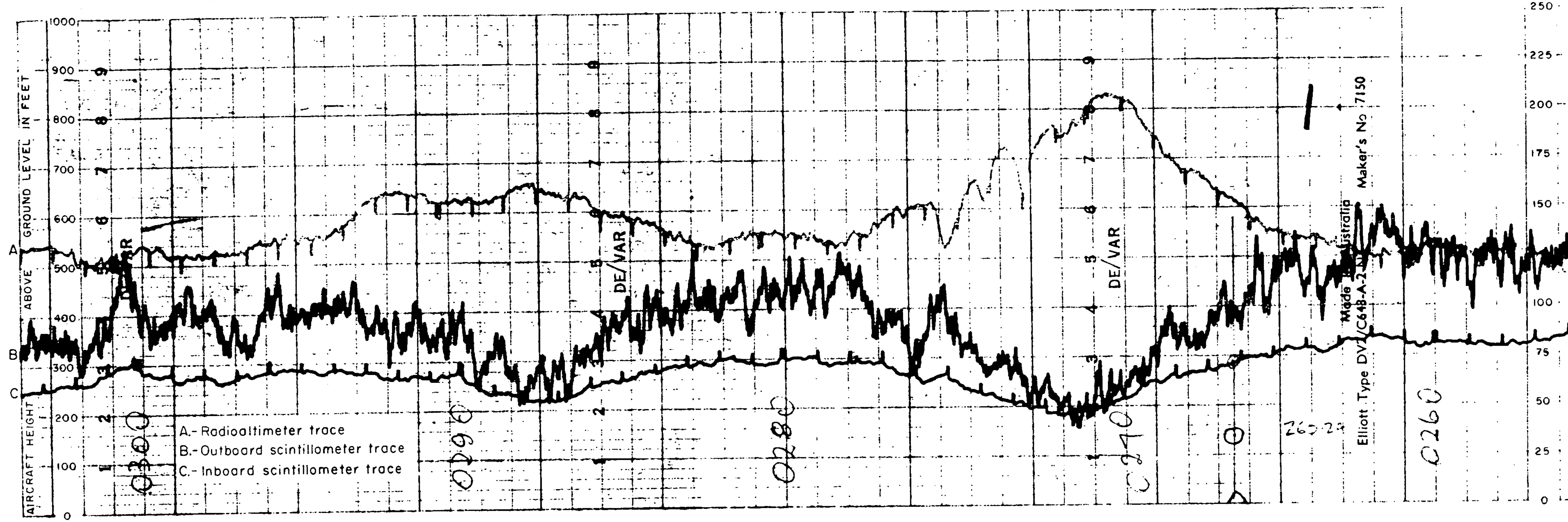



FIG. 2

## CORRELATION BETWEEN GROUND CLEARANCE AND RADIOACTIVE INTENSITY

(To face page 11)

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

To Accompany Record No. 1966/126

H54/B1-29

Diapiric structures throughout the area are not correlated with any change in depth to magnetic basement or in basement gradient. There is no obvious association between the rise of magnetic basement or in basement gradient. There is no obvious association between the rise of magnetic basement to the north and the Blinman diapir, and in the vicinity of the Oraparinna and Worumba diapirs the magnetic basement is more than 15,000 feet below mean sea level. This supports the theory that the Callanna Beds thicken considerably within the diapiric structures as each diapir lies on the axis of a major anticline.

A small zone of type 2 near the southern boundary of the area is correlated with an outcrop of Holowilena Ironstone. It is interesting to note that although this is the type section of the ironstone, its magnetic expression is minute compared with that seen in the ORROROO area. A similar ironstone outcrop is considered the source of an anomaly on line 47, about 14 miles north-east of Willippa Homestead. Approximately 3 miles south-east of this outcrop, a very steep anomaly recorded on a tie line is attributed to an outcrop of the Tindelpina Member.

The zones as shown in Plate 11 do not contain all the magnetic disturbance observed on the reduced profiles. As was experienced for the ORROROO area, some of this disturbance, because of its low amplitude and irregular distribution, remains unclassified. For example, a large diapir in the vicinity of the Arkaba Homestead to the north-west of the Worumba diapir appears as a low-order disturbance on some of the magnetic profiles crossing the diapir. The irregular distribution of this disturbance does not permit zoning. In addition, there are magnetic disturbances of the order of 5 to 10 gammas which are only visible on the original magnetometer records. An analysis of these disturbances might be useful in delineating unknown diapirs, and some have already been correlated with regions containing several small surface faults.

## 4. RADIOMETRIC RESULTS AND INTERPRETATION

Radiometric data were recorded by two scintillometers. The inboard scintillometer recorded the general level of radioactivity across 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 ORROROO and PARACHILNA areas in Plates 6 and 7. A north-south scale of 1:62,500 was used to improve data presentation. Errors in the position of the profile data are the same as those already stated for the presentation of the magnetic data. Contour presentation of the radiometric data is shown in Plates 8 and 9 together with the known geology. Some smoothing of the contours has been necessary to minimise contour distortions produced by a combination of errors. These include parallax error due to delay in instrument response resulting from the 10-second time-constant, temperature-affected instrumental drift, and variation in instrument sensitivity.

Great care has been necessary in the interpretation of the inboard scintillometer data. Ideally, any detector of radioactive intensity should maintain a constant ground clearance. The extreme ruggedness of the Flinders Ranges has rendered this impracticable, and variation in ground clearance was a major cause of the changes in recorded radioactive intensity. Figure 2 illustrates this correlation. However, topographic features can be expected to at least partially reflect surface geology, and some correlation was observed between the radiometric contours and stratigraphic boundaries. How much of this correlation is due to changes in the intrinsic radioactive content is difficult to assess. The regional trend of the radiometric contours changes from east-west in the south-eastern quadrant of the PARACHILNA area to a northerly direction in the north and east, reflecting the regional geological strike. To the south in the ORROROO area, the contours tend to cut across stratigraphic boundaries.

The general level of radioactive intensity for the survey area is 40 counts per second (c.p.s.). All regions enclosed by the 80 c.p.s. contours are mainly of Cainozoic age. With a single exception, they are confined to the south-east of the ORROROO area where a granitic body has been tentatively suggested to explain the magnetic pattern. Many radiometric intensity values in excess of 60 c.p.s were similarly detected over Cainozoic rocks. The Wilpena and Umberatana Groups generally have a slightly higher radioactive content than the Burra Group and Cambrian sequence.

In most of the area, values less than 20 c.p.s. signify a ground clearance greater than 1000 feet of the aircraft. An exception is the flat-lying Lake Torrens saltpan where the nominal ground-clearance of 500 ft was maintained and the low values indicate a low radioactive content.

Outboard scintillometer

The 16 anomalies from restricted sources detected by the outboard scintillometer are listed in Appendix 1 and shown in Plates 8 and 9. The criteria used in selecting these anomalies are also discussed in Appendix 1. The anomalies are classified into three categories, A, B, and C, examples of which are illustrated in Figure 3 in Appendix 1. No definite conclusions can be drawn regarding the sources of the anomalies but it is noted that two (Nos. 10 and 16) are associated with the interglacial sequence of the Umberatana Group and the rest are located in regions mapped as Cainozoic. Further investigation would necessitate geological inspection and a ground radiometric survey. However, only anomalies of categories A and B warrant investigation as those of category C might prove very difficult to detect by ground work, and their significance is marginal.

## 5. REFERENCES


CAMPANA, B. 1958 The Mt. Lofty-Olary region. Journ. Geol. Soc. Aust. 1957, v.5, PtII, pp. 3-27.

CAMPANA, B., and KING, D. 1958 Regional geology and mineral resources of the Olary Province. Bull. Geol. Surv. S. Aust. 34.

COATS, R.P. 1964 The geology and mineralisation of the Blinman Dome diapir. Rept. Invest. Geol. Surv. S. Aust. 26.

DALGARNO, C.R. 1964 Report on the Lower Cambrian stratigraphy of the Flinders Ranges, S.A. Trans. Roy. Soc. S. Aust. 88, pp. 129-144.

DICKINSON, S.B., and SPRIGG, R.C. 1953 Geological structure of South Australia in relation to mineralisation. In GEOLOGY OF AUSTRALIAN ORE DEPOSITS. Aust. Inst. Min. Metall.

HOWARD, P.F. 1951 The basic igneous rocks of the Blinman Dome. Trans. Roy. Soc. S. Aust. 74, pp. 165-188.

MAWSON, D. 1942 The structural character of the Flinders Ranges. Trans. Roy. Soc. S. Aust. 66.

MILES, K. 1954 The geology and iron ore resources of the Middleback Range area. Bull. Geol. Surv. S. Aust. 33.

MIRAMS, R.C. 1961 Field relationships of the Anabama Granite. Trans. Roy. Soc. S. Aust. 85, pp121-154.

MIRAMS, R.C. 1962 The geology of the Manunda military sheet. Rept. Invest. Geol. Surv. S. Aust. 19.

MUMME, I.A. 1961 Geophysical investigation of the Blinman Dome. Trans. Roy. Soc. S. Aust. 85, pp 7-12.

PETERS, L.J. 1949 The direct approach to magnetic interpretation and its practical application. Geophysics 14(3), 290-320.

S. A. MINES DEPARTMENT 1952 Total intensity contour maps. Aeromagnetic survey of Eyre Peninsula.

S. A. MINES DEPARTMENT 1957 Total intensity contour maps. Aeromagnetic survey of northern Port Augusta and southern Torrens 1:250,000 map areas.

S. A. MINES DEPARTMENT 1959 Total intensity contour maps. Aeromagnetic survey of part of the Olary 1:250,000 map area.

S. A. MINES DEPARTMENT 1963 Total intensity contour maps. Aeromagnetic survey including the Frome 1:250,000 map area.

THOMSON, B.P. 1964a Geology and mineralisation in South Australia. S. Aust. Dept. Mines. Rept. 58/105.

THOMSON, B.P. 1964b The lower boundary of the Adelaide System and older basement relationships in South Australia. S. Aust. Dept. Mines. Rept. D.M. 433A/64.

WEBB, B.P. 1960 Diapiric structures in the Flinders Ranges, S.A. Aust. Journ. Sci. 22.

WEBB, B.P. 1961 The geological structure of the Blinman Dome. Trans. Roy. Soc. S. Aust. 85, pp 1-6.

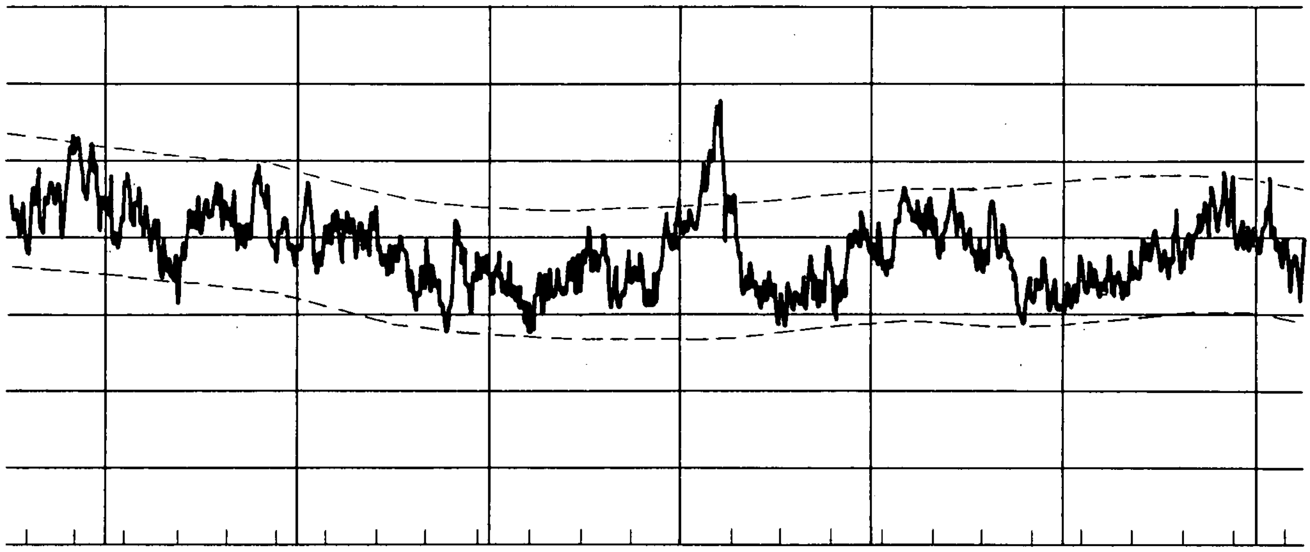
WELLS, R. 1962a Burra area airborne magnetic and radiometric survey, S.A. 1960. Bur. Min. Resour. Aust. Rec. 1962/97.

WELLS, R. 1962b Curnamona airborne magnetic survey, SA 1962. Bur. Min. Resour. Aust. Rec. 1962/160.

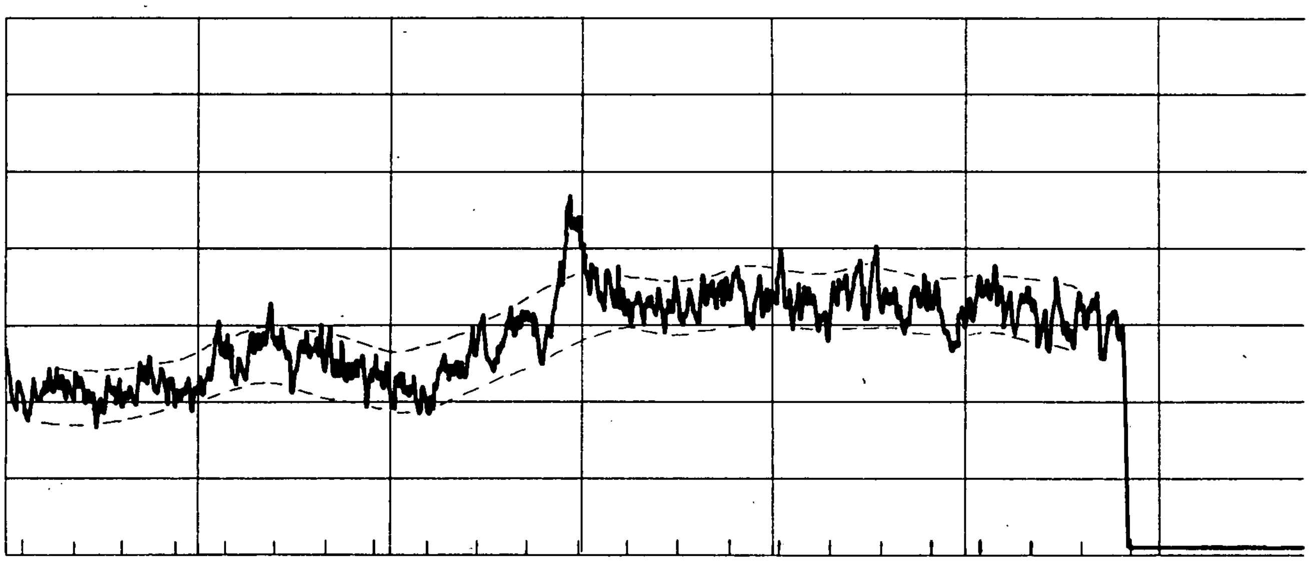
YOUNG, G.A. 1963 Chowilla airborne magnetic and radiometric survey, SA 1961. Bur. Min. Resour. Aust. Rec. 1963/25.

YOUNG, G.A. 1964 Andamooka and Torrens airborne magnetic and radiometric survey, SA 1962. Bur. Min. Resour. Aust. Rec. 1964/31.

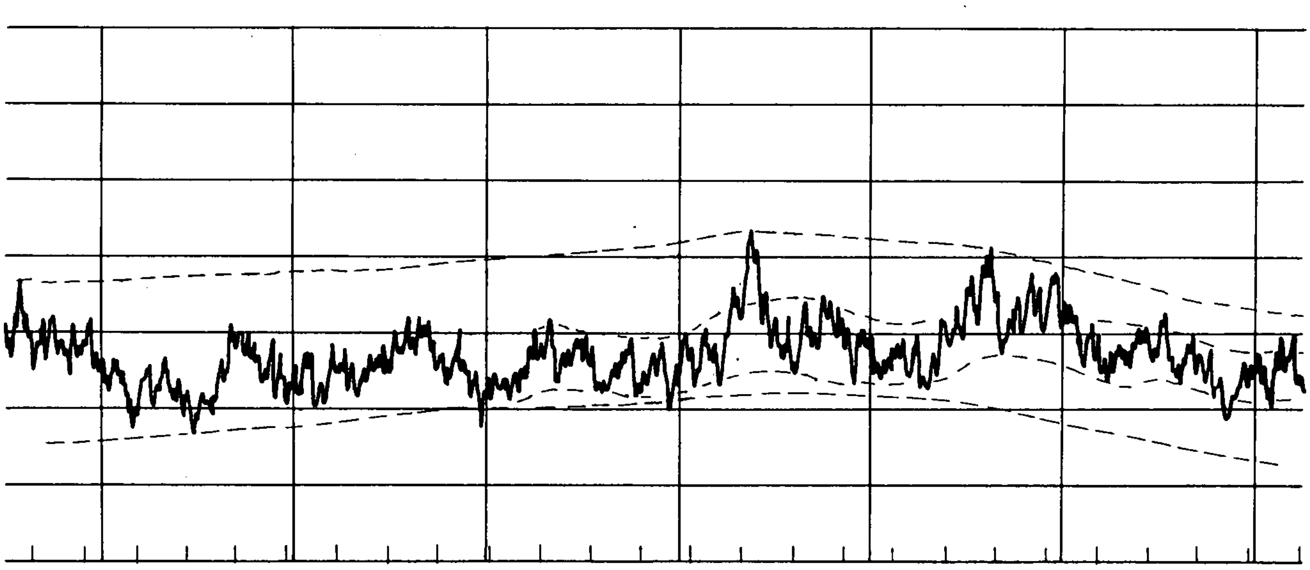
(To face page 15)



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



B. Anomaly significant with respect to statistical noise envelope.



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

FIG. 3

## TYPES OF RADIOMETRIC ANOMALIES

*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.* H54/B1-30

To Accompany Record No. 1966/126

# APPENDIX 1

## Outboard radiometric anomalies

### Anomaly interpretation criteria

Amplitude. For an anomaly to be resolved from the normal gamma ray background noise, the amplitude must be statistically significant. The acceptance level is three times the standard deviation of the background noise.

Gamma ray background noise. Two distinct types of gamma ray background noise are recognised, which are produced by :

1. Statistical variation of the recorded gamma ray intensity, from a homogeneous source. The standard deviation of the count rate is given by -

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

, where N = count rate, and T = 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.

Examples of anomalies of different categories are shown in Figure 3.

Form. Anomaly shape is a function of source configuration and location relative to the detector. The width of an anomaly at half peak amplitude is related to these factors, and the acceptance limits set are :

Anomaly width at half 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, limited by sources with radius 300 feet, centred on the aircraft's line of flight, and point sources located within 300 feet of the aircraft's line of flight.

TABLE 1

Outboard radiometric anomalies

| Anomaly No. | Line No. | Fiducial No. | Half peak width (s) | Amplitude (x S.D.) | Anomaly Classification |
|---|---|---|---|---|---|
| 1 | 4 E | 524.1 | 4.0 | 5 | A |
| 2 | 5 W | 428.0 | 3.5 | 5 | B |
| 3 | 7 W | 1737.1 | 3.5 | 4 | C |
| 4 | 18 W | 444.7 | 4.0 | 4 | C |
| 5 | 29 E | 1448.1 | 3.5 | 6 | B |
| 6 | 31 E | 931.0 | 4.0 | 6 | B |
| 7 | 33 E | 482.1 | 3.5 | 4 | C |
| 8 | 41 E | 36.8 | 3.5 | 5 | C |
| 9 | 77 E | 1028.1 | 4.0 | 4 | B |
| 10 | 86 W | 822.9 | 4.0 | 4 | B |
| 11 | 94 W | 349.9 | 3.5 | 6 | C |
| 12 | 103 E | 1084.7 | 3.5 | 4 | C |
| 13 | 108 E | 1495.8 | 3.5 | 5 | B |
| 14 | 115 E | 234.2 | 3.5 | 4 | A |
| 15 | 123 W | 1471.0 | 4.0 | 5 | B |
| 16 | 128 W | 812.4 | 3.5 | 5 | B |

# APPENDIX 2

## Operational details

### Staff

| | |
|---|---|
| Party leader | : D. B. Tipper |
| Geophysicist | : W. A. Finney |
| Senior radio technician | : P. B. Turner |
| Geophysical assistants | : K. A. Mort<br>D. Park<br>C. I. Parkinson |
| Drafting assistant | : D. Lankester |
| Draftsmen | : G. Semmens, D. Copley, P. Williamson (S.A. Mines Department) |
| Pilots | : Captain T. D. Newman, Captain R. Smythe, First Officer D. Spiers (T.A.A.) |
| Aircraft maintenance engineer | : W. Briggs |

### Equipment

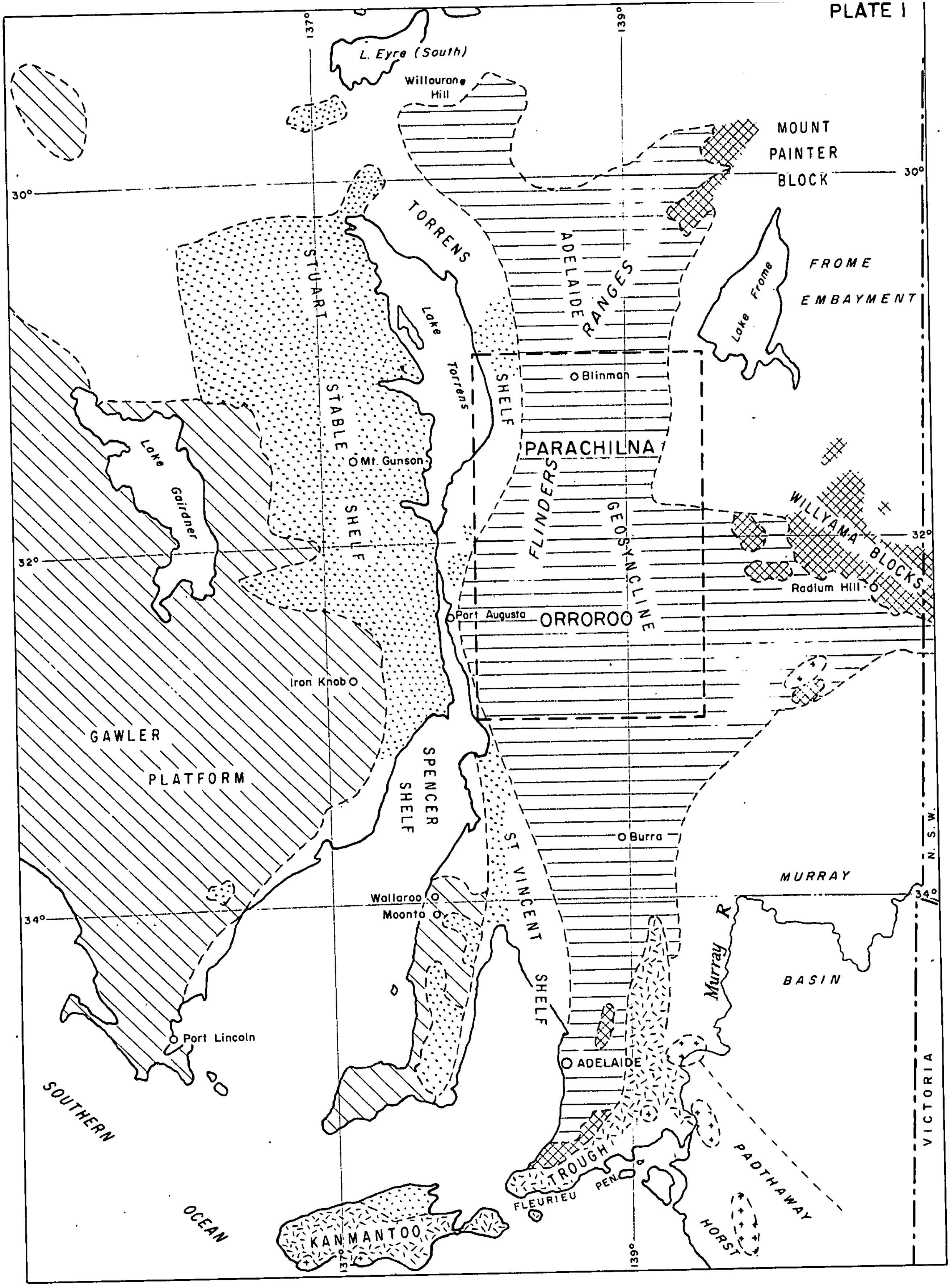
| | |
|---|---|
| Aircraft | : DC 3 VH-MIN |
| Magnetometer | : MFS-5 saturable core fluxgate, tailboom installation, coupled to 'Speedomax' and digital recorders. |
| Scintillographs | : Twin crystal MEL scintillation detector heads inboard and outboard, the latter suspended from a cable 290 feet below the aircraft. Outputs coupled to a De Var recorder. |
| Camera | : BMR 35-mm strip. |
| Radio altimeter | : STR 30B, frequency modulated type, coupled to a De Var recorder. |
| Air position indicator | : Track recorded by integration of aircraft heading and air speed, on a De Var recorder. |
| Storm warning detector | : MFD-3 saturable core fluxgate magnetometer, ground installation. |

### Survey specifications

| | |
|---|---|
| Altitude | : Nominal 500 feet above ground level |
| Line spacing | : 1 statute mile |
| Line orientation | : East and west |

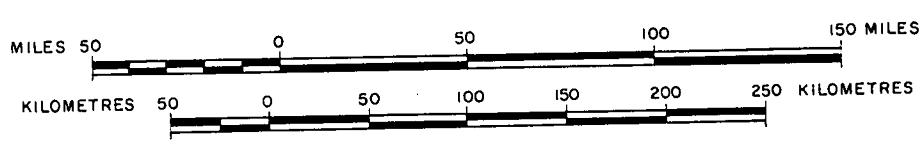
| | | |
|---|---|---|
| Tie system | : | Single lines spaced 15 miles apart. Double lines near eastern and western boundaries of each 1:250,000 map area. |
| Tie line orientation | : | Alternately north and south |
| Navigational control | : | Aerial photographs supplied by S.A. Mines Department |
| **Record sensitivities :** | | |
| MFS-5 | : | 500 gammas full scale (10 inches) |
| Inboard scintillometer | : | 250 counts per second full scale (4 inches) |
| Outboard scintillometer | : | 250 counts per second full scale (4 inches) |
| Radio altimeter | : | 1000 feet full scale (4 inches) |
| MFD-3 | : | 100 gammas full scale (4.5 inches) |
| Scintillometer time constants : | | |
| Inboard | : | 10 seconds |
| Outboard | : | 1 second |

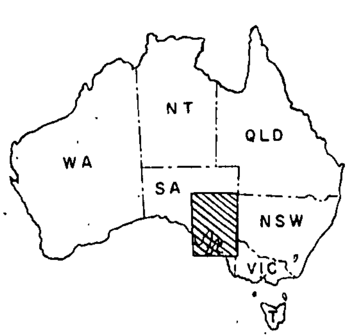
PLATE 1




AIRBORNE SURVEY, ORROROO - PARACHILNA, S A 1965

# LOCALITY MAP




REFERENCE

- POST CAMBRIAN SEDIMENTS OF YOUNGER BASINS. MESOZOIC - CAINOZOIC
- LOWER PALAEOZOIC GRANITE
- LOWER PALAEOZOIC KANMANTOO TROUGH SEDIMENTS
- UPPER PROTEROZOIC - CAMBRIAN FOLDED SEDIMENTS OF THE ADELAIDE GEOSYNCLINE
- UPPER PROTEROZOIC - CAMBRIAN THIN FLAT LYING OR GENTLY FOLDED SHELF SEDIMENTS
- PROTEROZOIC - ARCHAEAN ? MOBILE CRYSTALLINE BASEMENT OF ADELAIDE GEOSYNCLINE
- PROTEROZOIC - ARCHAEAN CRYSTALLINE BASEMENT OF PLATFORMS
- SURVEY AREA BOUNDARY

GEOLOGY AFTER DEPARTMENT OF MINES, S A

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. H54/B1-31
TO ACCOMPANY RECORD No. 1966/126

# ORROROO

SOUTH AUSTRALIA

PLATE 2


AIRBORNE SURVEY, ORROROO – PARACHILNA, SA 1965

## TOTAL MAGNETIC INTENSITY PROFILES

LOCATION DIAGRAM

INDEX TO ADJOINING SHEETS

TORRENS | PARACHILNA | CURNAMONA

EAST-WEST SCALE

MILES 5 0 5 10 15 20 MILES

APPROX. PROFILE SCALE

500 gammas

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 FLIGHT-LINES ARE IDEALISED, AND SERVE AS BASELINES TO THE PROFILES. THEY APPROXIMATE THE ACTUAL FLIGHT PATH WITH A PROBABLE ERROR OF ± ½ MILE.

# PARACHILNA
SOUTH AUSTRALIA

PLATE 3


AIRBORNE SURVEY, ORROROO-PARACHILNA, SA 1965

## TOTAL MAGNETIC INTENSITY PROFILES

LOCATION DIAGRAM


INDEX TO ADJOINING SHEETS

| | | |
|---|---|---|
| ANDAMOOKA | COPLEY | FROME |
| TORRENS | PARACHILNA | CURNAMONA |
| PORT AUGUSTA | ORROROO | OLARY |

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

500 gammas
250
0

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 FLIGHT-LINES ARE IDEALISED, AND SERVE AS BASELINES TO THE PROFILES. THEY APPROXIMATE THE ACTUAL FLIGHT PATH WITH A PROBABLE ERROR OF ±1/2 MILE.*

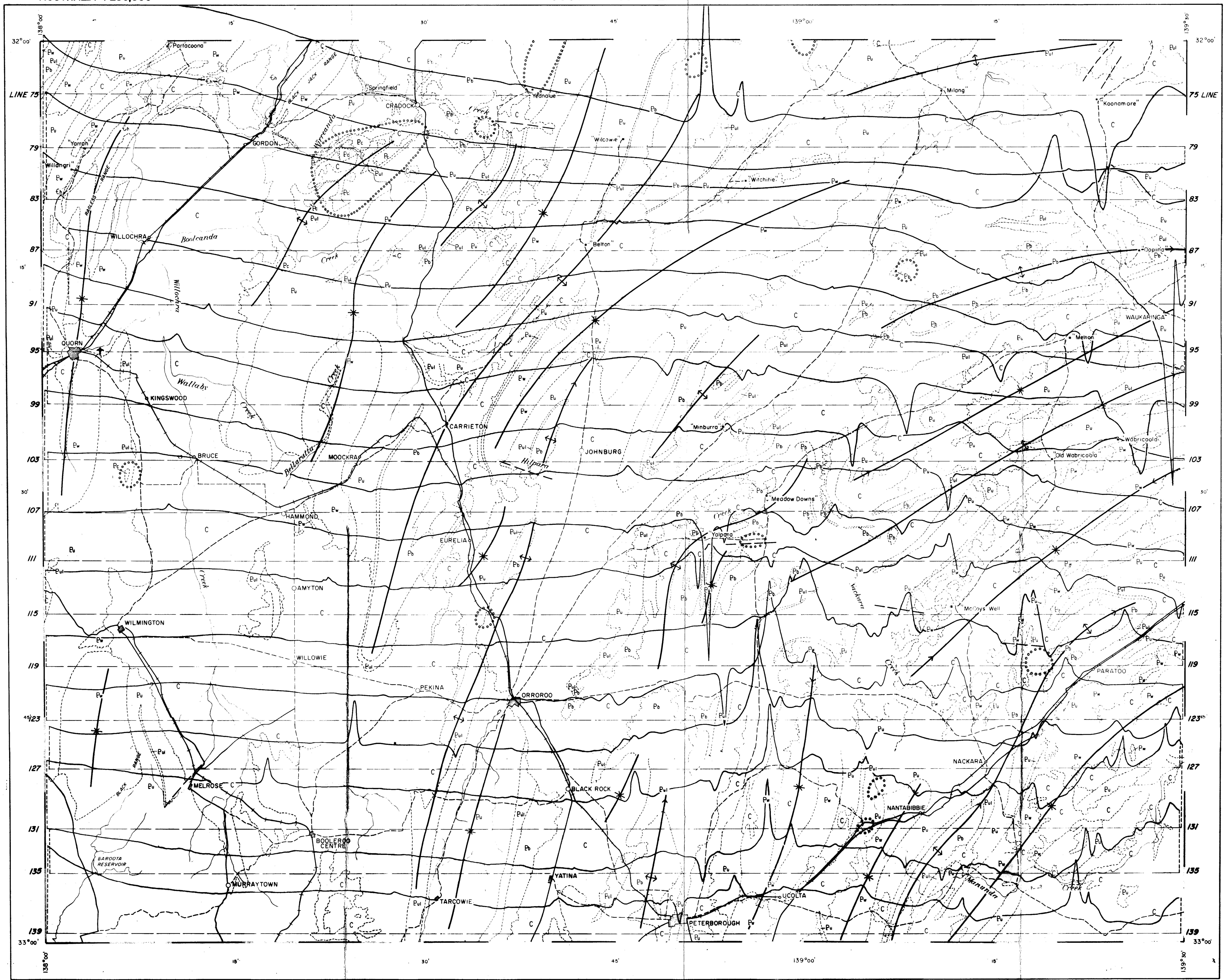
*THE PROFILES HAVE BEEN CORRECTED FOR THE SOUTH COMPONENT OF A REGIONAL GRADIENT IN TOTAL MAGNETIC INTENSITY. THIS COMPONENT AMOUNTS TO 8·5 GAMMAS PER MILE.*

*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics* **H54/BI-22**
TO ACCOMPANY RECORD No. 1966/126

# ORROROO
## SOUTH AUSTRALIA

AUSTRALIA 1:250,000

PLATE 4




BASED ON 154/80-8

BASED ON 154/B1-4

## GEOLOGICAL LEGEND

| | | |
|---|---|---|
| CAINOZOIC | C | Superficial deposits |
| CAMBRIAN | €h | Hawker Group |
| UPPER PROTEROZOIC | Pw | Wilpena Group |
| | Pu | Interglacial sequence and upper glacial unit (Umberatana Group) |
| | Pul | Lower glacial unit (Umberatana Group) |
| | Pb | Burra Group |
| | Pc | Callanna Beds within diapiric structures |

Geological boundary

Inferred fault

Zone of suspected diapirism

Anticline

Syncline

Note.- Discontinued geological boundaries indicate incomplete mapping.

**GEOLOGY AFTER DEPARTMENT OF MINES, S.A.**

## TOPOGRAPHICAL LEGEND

River or creek

Main road

Road or track

Railway

Built-up area

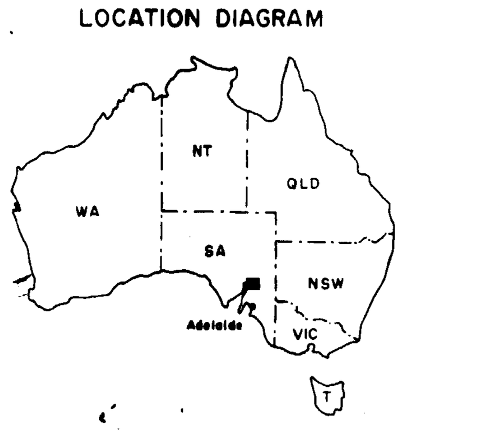
Named place

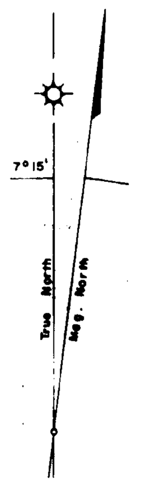
Railway station

Homestead

Aerodrome or landing ground

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

| | | |
|---|---|---|
| TORRENS | PARACHILNA | CURNAMONA |
| PORT AUGUSTA | ORROROO | OLARY |
| WHYALLA | BURRA | CHOWILLA |

AIRBORNE SURVEY, ORROROO-PARACHILNA, SA 1965

# TOTAL MAGNETIC INTENSITY PROFILES AND GEOLOGY

MILES 5 0 5 10 15 20 MILES

KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

APPROX. PROFILE SCALE

500 gammas

250

0

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

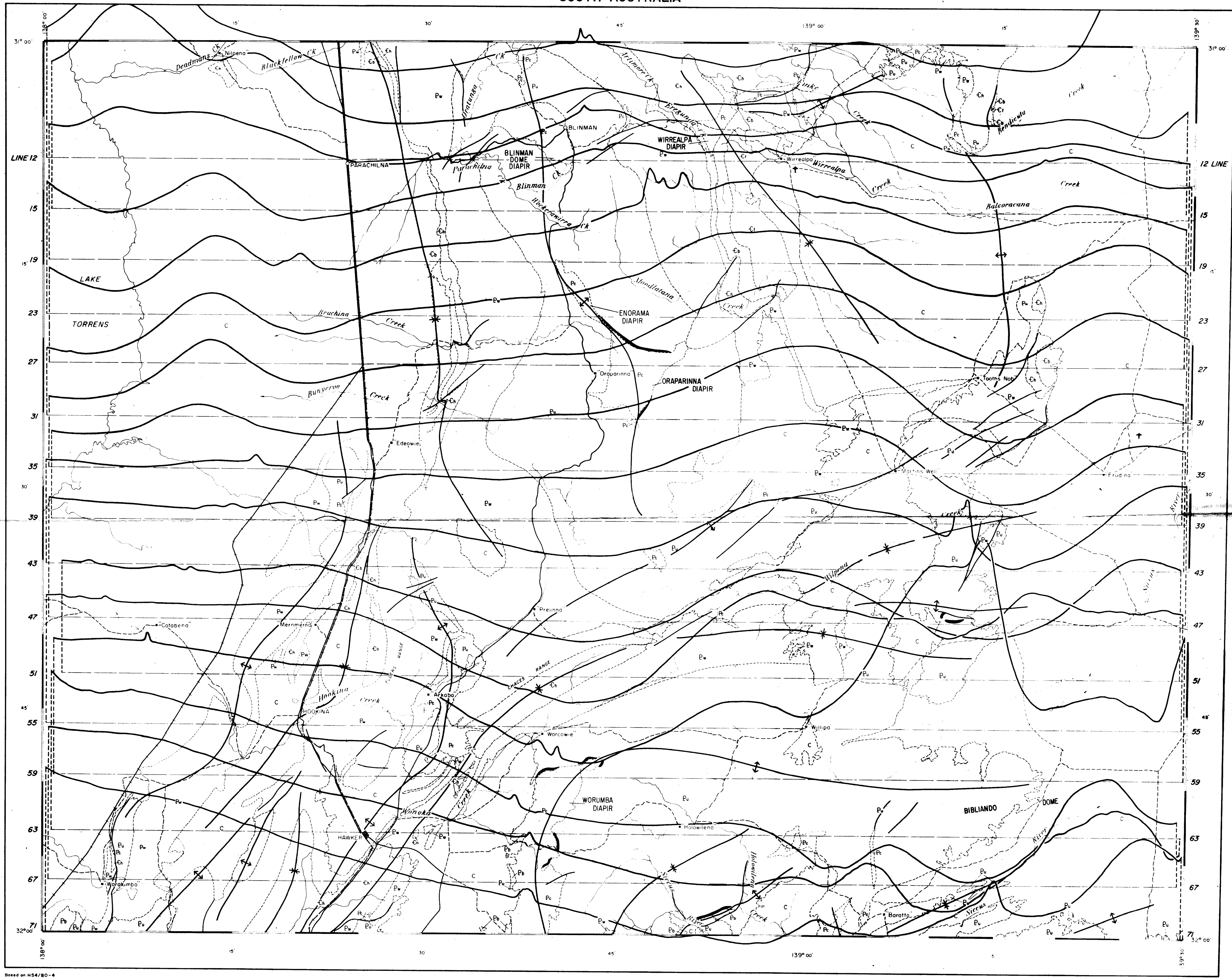
*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics* 154/B1-8

TO ACCOMPANY RECORD No.1966/126

AUSTRALIA 1:250,000

# PARACHILNA
## SOUTH AUSTRALIA

PLATE 5




### GEOLOGICAL LEGEND

| | | |
|---|---|---|
| CAINOZOIC | C | Superficial deposits |
| CAMBRIAN | Єf | Lake Frome Group |
| | Єb | Billy creek Formation |
| | Єh | Hawker Group |
| UPPER PROTEROZOIC | Pw | Wilpena Group |
| | Pu | Umberatana Group |
| | Pb | Burra Group |
| | Pc | Callanna Beds within diapiric structures |

Geological boundary

Fault

Ironstone Beds

Anticline

Syncline

GEOLOGY AFTER DEPARTMENT OF MINES, S.A.

### TOPOGRAPHICAL LEGEND

River or creek

Main road

Road or track

Railway

Railway, abandoned

Built-up area

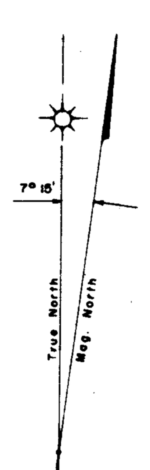
Named place

Railway station

Homestead

Aerodrome or landing ground

### LOCATION DIAGRAM


### INDEX TO ADJOINING SHEETS

| | | |
|---|---|---|
| ANDAMOOKA | COPLEY | FROME |
| TORRENS | PARACHILNA | CURNAMONA |
| PORT AUGUSTA | ORROROO | OLARY |

AIRBORNE SURVEY, ORROROO–PARACHILNA, SA 1965

# TOTAL MAGNETIC INTENSITY PROFILES AND GEOLOGY

APPROX. PROFILE SCALE

500 gammas

250

0

MILES

KILOMETRES

### 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 FLIGHT-LINES ARE IDEALISED, AND SERVE AS BASELINES TO THE PROFILES. THEY APPROXIMATE THE ACTUAL FLIGHT PATH WITH A PROBABLE ERROR OF ± 1/2 MILE. PROFILES RECORDED AT INTERVALS OF FOUR MILES ARE SHOWN ON THE MAP*

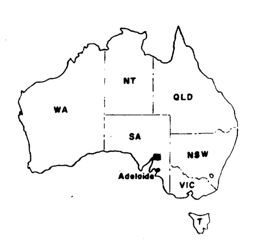
*THE PROFILES HAVE BEEN CORRECTED FOR THE SOUTH COMPONENT OF A REGIONAL GRADIENT IN TOTAL INTENSITY. THIS COMPONENT AMOUNTS TO 8·5 GAMMAS PER MILE*


*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.* H54/B1–32

TO ACCOMPANY RECORD No.1966/126

# ORROROO
SOUTH AUSTRALIA


LOCATION DIAGRAM



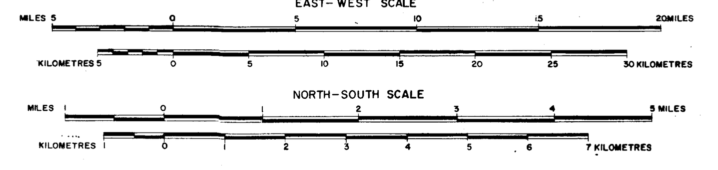

INDEX TO ADJOINING SHEETS

| | | |
|---|---|---|
| TORRENS | PARACHILNA | CURNAMONA |
| PORT AUGUSTA | ORROROO | OLARY |
| WHYALLA | BURRA | CHOWILLA |

AIRBORNE SURVEY, ORROROO – PARACHILNA, SA 1965

## RADIOMETRIC PROFILES

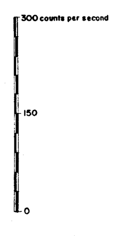
EAST – WEST SCALE




NORTH – SOUTH SCALE



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 ± ½ MILE.*

*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.* I54/BI–5
TO ACCOMPANY RECORD No. 1966/126

# PARACHILNA

SOUTH AUSTRALIA

**PLATE 7**

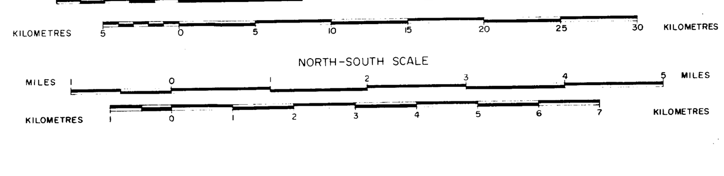

LOCATION DIAGRAM


INDEX TO ADJOINING SHEETS

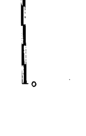
| | | |
|---|---|---|
| ANDAMOOKA | COPLEY | FROME |
| TORRENS | PARACHILNA | CURNAMONA |
| PORT AUGUSTA | ORROROO | OLARY |

AIRBORNE SURVEY, ORROROO – PARACHILNA, SA 1965

## RADIOMETRIC PROFILES




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

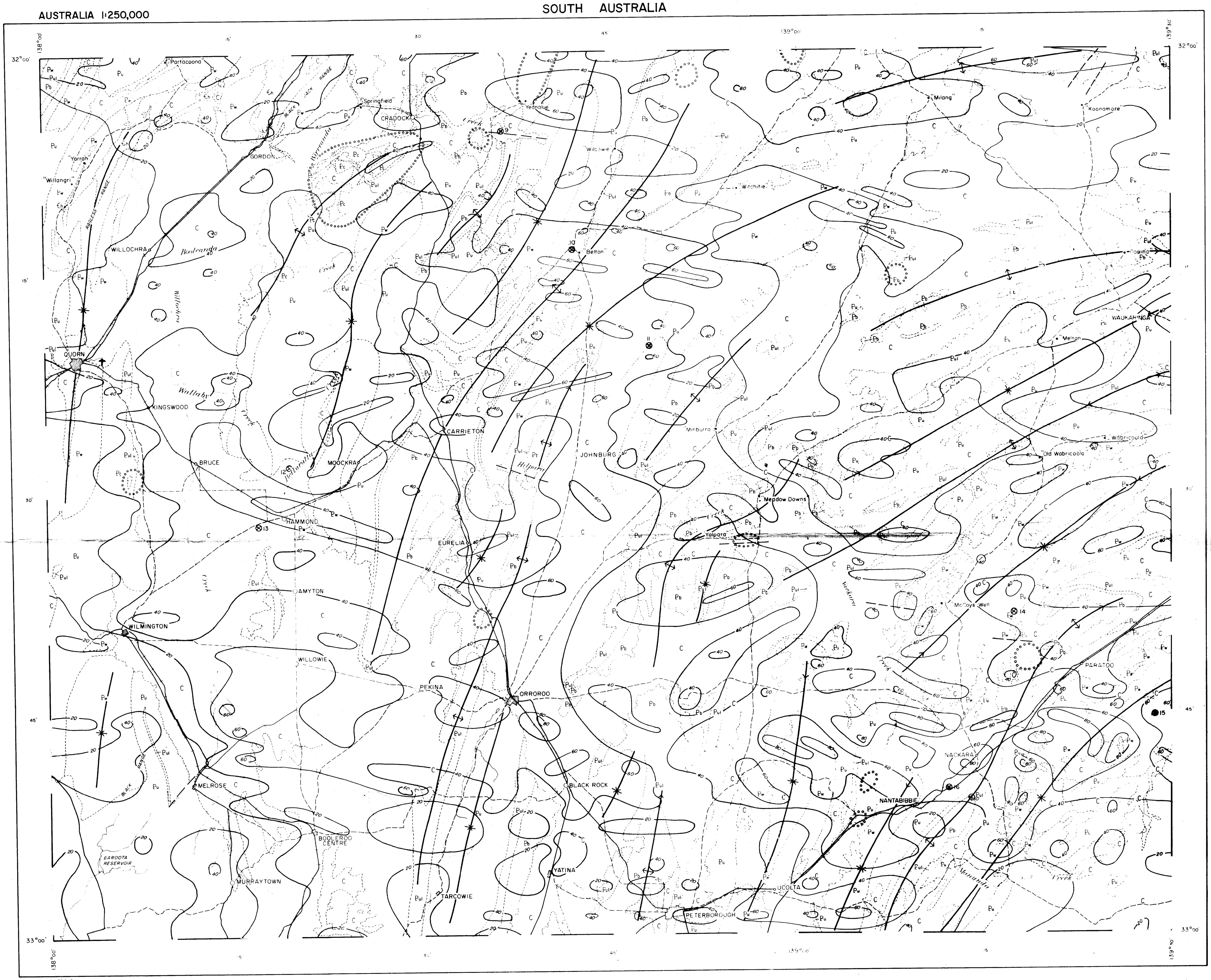
*THE FLIGHT-LINES ARE IDEALISED, AND SERVE AS BASELINES TO THE PROFILES. THE RADIOMETRIC DATA HAS BEEN POSITIONED WITH A PROBABLE ERROR OF ±1/2 MILE.*

*Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics* **H54/B1-24**

TO ACCOMPANY RECORD No. 1966/126

# ORROROO
## SOUTH AUSTRALIA

AUSTRALIA 1:250,000




BASED ON 154/B0-8
BASED ON 154/B1-7

GEOLOGICAL LEGEND

| | | | |
|---|---|---|---|
| CAINOZOIC | C | Superficial deposits | |
| CAMBRIAN | Єh | Hawker Group | |
| UPPER PROTEROZOIC | Pw | Wilpena Group | |
| | Pu | Interglacial sequence and upper glacial unit | Umberatana Group |
| | Pul | Lower glacial unit | |
| | Pb | Burra Group | |
| | Pc | Callanna Beds within diapiric structures | |

Geological boundary

Inferred fault

Zone of suspected diapirism

Anticline

Syncline

Note - Discontinued geological boundaries indicate incomplete mapping.

GEOLOGY AFTER DEPARTMENT OF MINES, S.A.

TOPOGRAPHICAL LEGEND

River or creek

Main road

Road or track

Railway

Built-up area

Named place

Railway station

Homestead

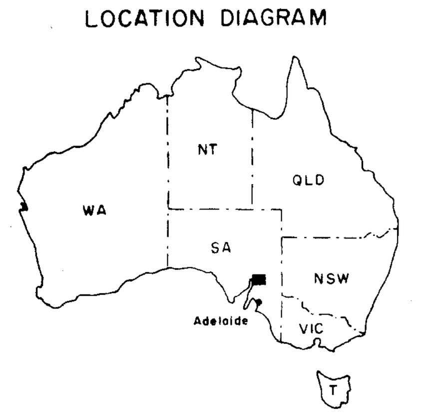
Aerodrome or landing ground

GEOPHYSICAL LEGEND

20 40 60 Radiometric contours, counts per second.

12⊗ Radiometric anomaly restricted source (Anomalies are numbered for reference only)

LOCATION DIAGRAM




INDEX TO ADJOINING SHEETS

| | | |
|---|---|---|
| TORRENS | PARACHILNA | CURNAMONA |
| PORT AUGUSTA | ORROROO | OLARY |
| WHYALLA | BURRA | CHOWILLA |

AIRBORNE SURVEY, ORROROO-PARACHILNA, SA 1965

# RADIOMETRIC RESULTS
AND
# GEOLOGY

MILES 5 0 5 10 15 20 MILES

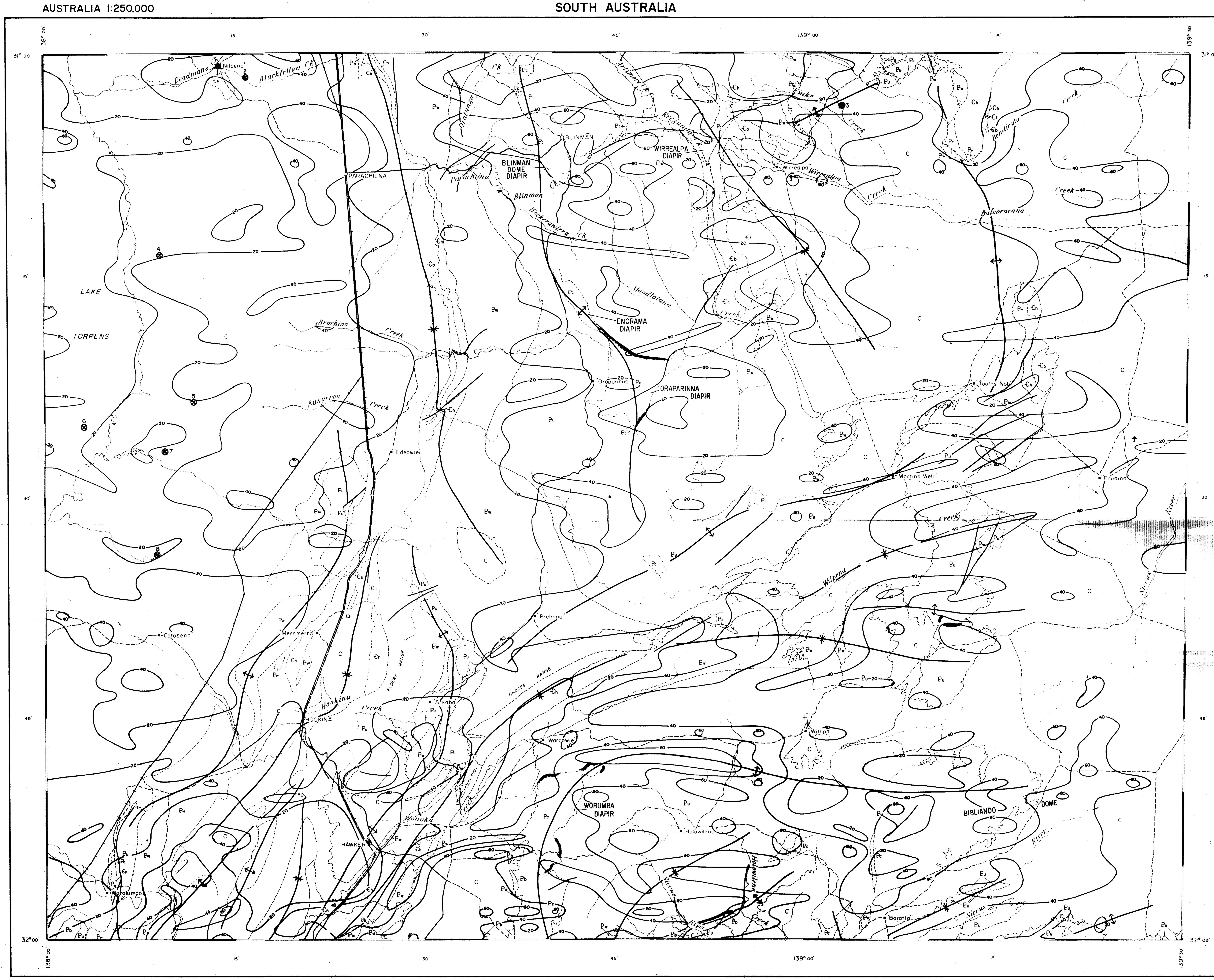
KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics 154/B1-10
TO ACCOMPANY RECORD No. 1966/126

AUSTRALIA 1:250,000

# PARACHILNA
## SOUTH AUSTRALIA

PLATE 9




### GEOLOGICAL LEGEND

CAINOZOIC
- C — Superficial deposits

CAMBRIAN
- Єf — Lake Frome Group
- Єb — Billy creek Formation
- Єh — Hawker Group

UPPER PROTEROZOIC
- Pw — Wilpena Group
- Pu — Umberatana Group
- Pb — Burra Group
- Pc — Callanna Beds within diapiric structures

- Geological boundary
- Fault
- Ironstone Beds
- Anticline
- Syncline

GEOLOGY AFTER DEPARTMENT OF MINES, S.A.

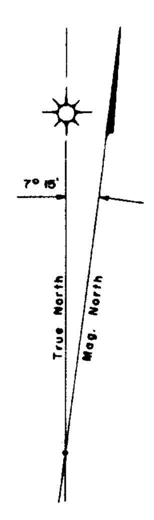
### TOPOGRAPHICAL LEGEND

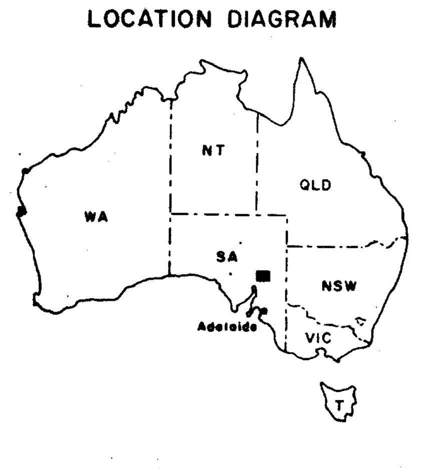
- River or creek
- Main road
- Road or track
- Railway
- Railway, abandoned
- Built-up area
- Named place
- Railway station
- Homestead
- Aerodrome or landing ground

### GEOPHYSICAL LEGEND

- 20 / 40 / 60 — Radiometric contours, counts per second.
- 6 ⊗ — Radiometric anomaly restricted source (Anomalies are numbered for reference only)

LOCATION DIAGRAM




INDEX TO ADJOINING SHEETS

| | | |
|---|---|---|
| ANDAMOOKA | COPLEY | FROME |
| TORRENS | PARACHILNA | CURNAMONA |
| PORT AUGUSTA | ORROROO | OLARY |

AIRBORNE SURVEY, ORROROO–PARACHILNA, SA 1965

# RADIOMETRIC RESULTS AND GEOLOGY

MILES 5 0 5 10 15 20 MILES

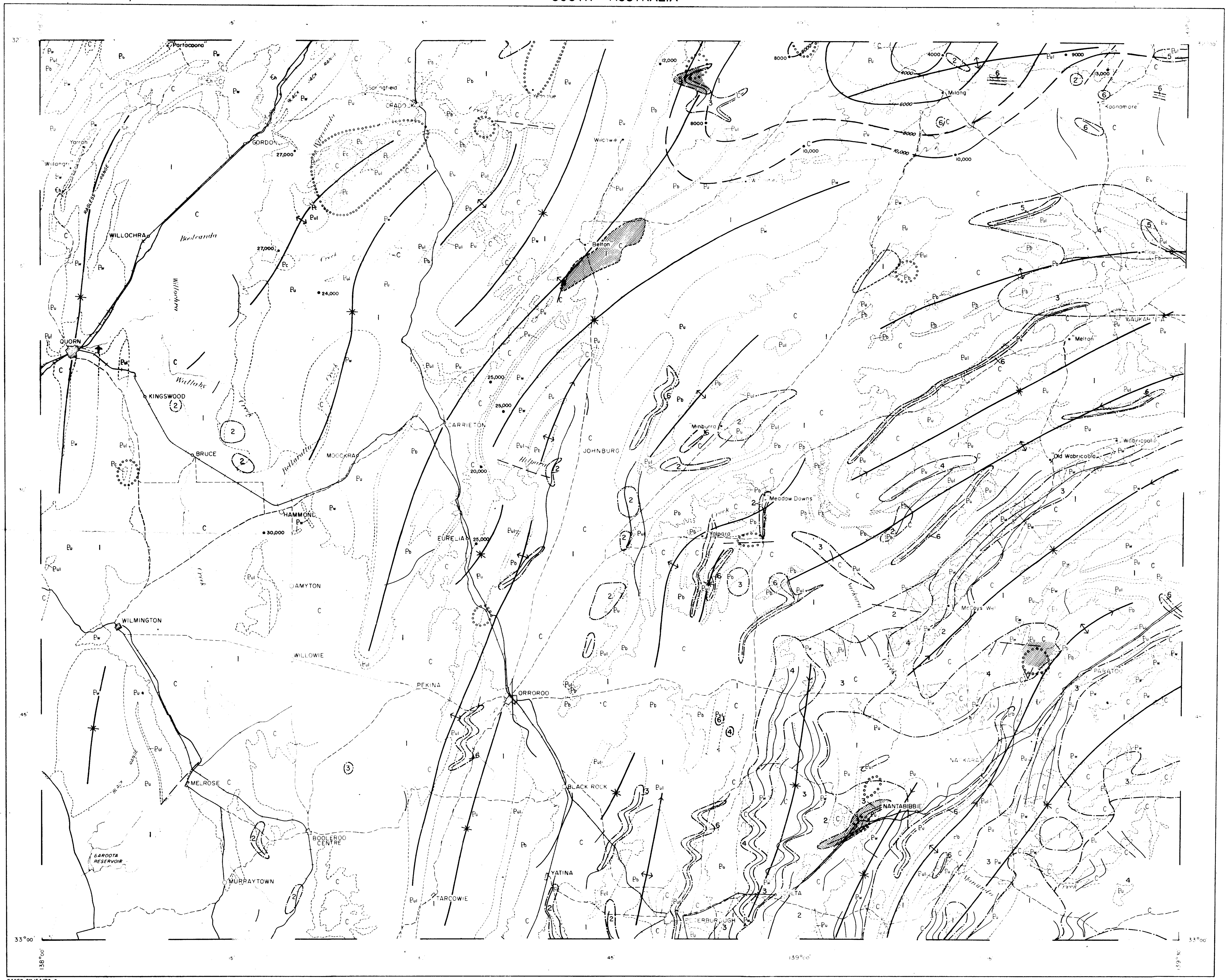
KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. H54/B1–34
TO ACCOMPANY RECORD No. 1966/126

AUSTRALIA 1:250,000

# ORROROO
## SOUTH AUSTRALIA

PLATE 10




BASED ON 154/80-8
BASED ON 154/81-6

### GEOLOGICAL LEGEND

| | | |
|---|---|---|
| CAINOZOIC | C | Superficial deposits |
| CAMBRIAN | Єh | Hawker Group |
| UPPER PROTEROZOIC | Pw | Wilpena Group |
| | Pu | Interglacial sequence and upper glacial unit (Umberatana Group) |
| | Pul | Lower glacial unit (Umberatana Group) |
| | Pb | Burra Group |
| | Pc | Callanna Beds within diapiric structures |

Geological boundary
Inferred fault
Zone of suspected diapirism
Anticline
Syncline

Note: Discontinued geological boundaries indicate incomplete mapping.

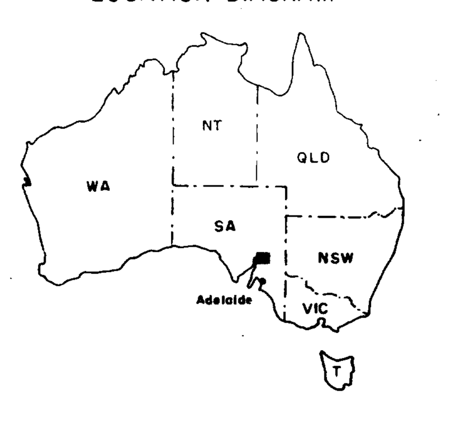
### TOPOGRAPHICAL LEGEND

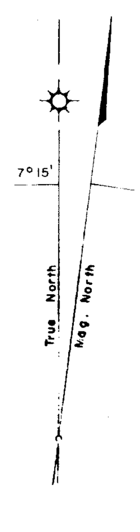
River or creek
Main road
Road or track
Railway
Built-up area
Named place
Railway station
Homestead
Aerodrome or landing ground

### GEOPHYSICAL LEGEND

Magnetic trend (positive)
Magnetic trend (negative)
Zonal boundary
Intrazonal boundary
Possible diapiric structures
• 2000 Basement depth estimate
2000 Basement depth contour

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

| | | |
|---|---|---|
| TORRENS | PARACHILNA | CURNAMONA |
| PORT AUGUSTA | ORROROO | OLARY |
| WHYALLA | BURRA | CHOWILLA |

AIRBORNE SURVEY, ORROROO–PARACHILNA, SA 1965

# MAGNETIC INTERPRETATION AND GEOLOGY

MILES 5 0 5 10 15 20 MILES

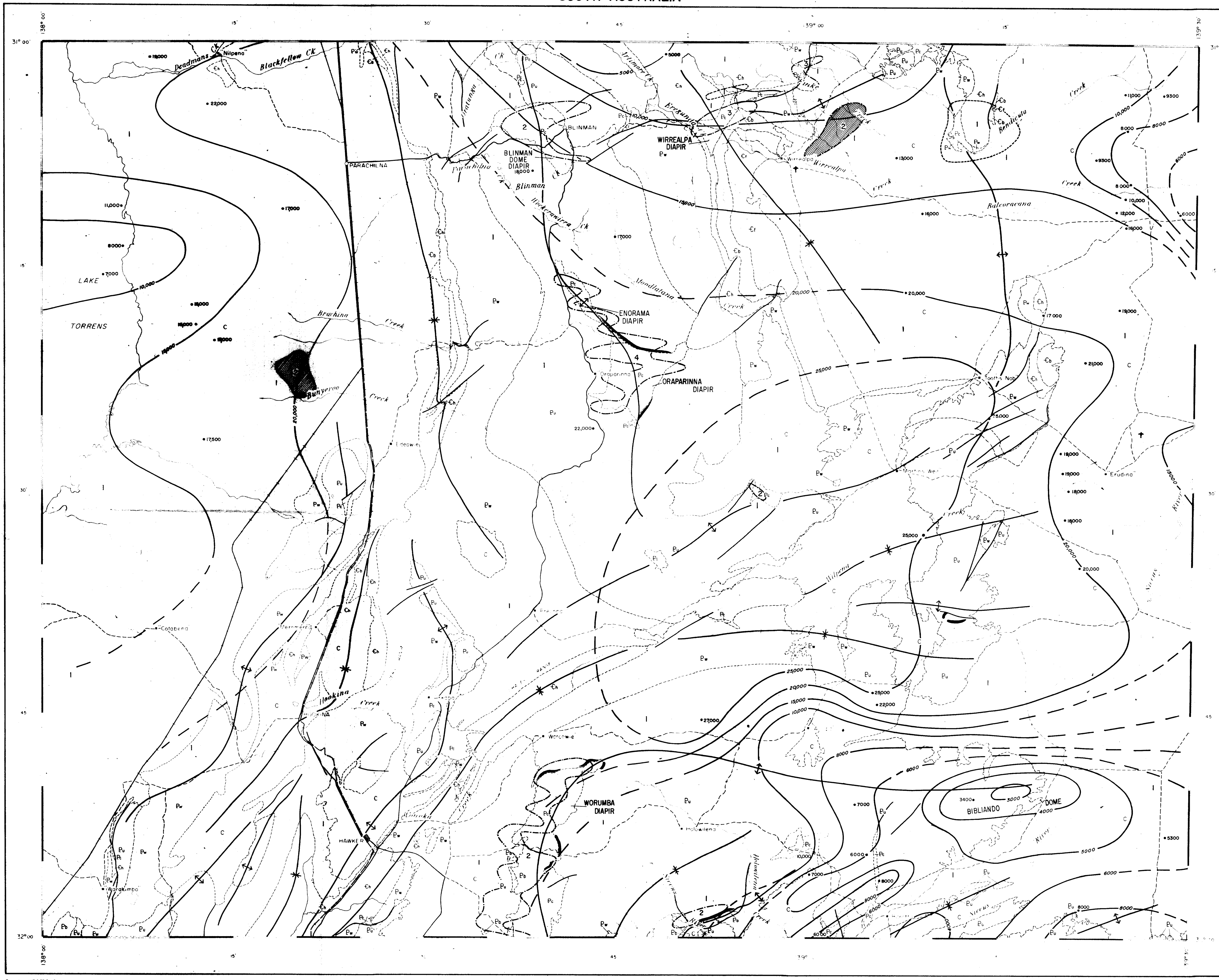
KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics 154/B1-9
TO ACCOMPANY RECORD No. 1966/126

AUSTRALIA 1:250,000

# PARACHILNA
## SOUTH AUSTRALIA

PLATE II




GEOLOGICAL LEGEND

| | | |
|---|---|---|
| CAINOZOIC | C | Superficial deposits |
| CAMBRIAN | Єf | Lake Frome Group |
| | Єb | Billy creek Formation |
| | Єh | Hawker Group |
| UPPER PROTEROZOIC | Pw | Wilpena Group |
| | Pu | Umberatana Group |
| | Pb | Burra Group |
| | Pc | Callanna Beds within diapiric structures |

Geological boundary
Fault
Ironstone Beds
Anticline
Syncline

GEOLOGY AFTER DEPARTMENT OF MINES, S.A.

TOPOGRAPHICAL LEGEND

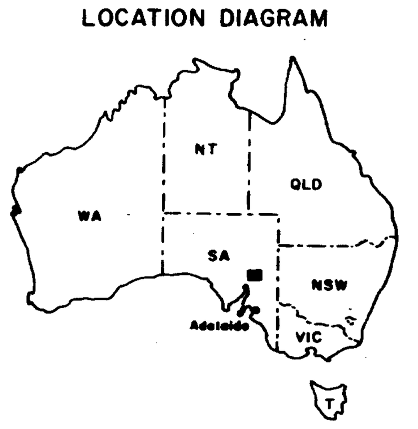
River or creek
Main road
Road or track
Railway
Railway, abandoned
Built-up area
Named place
Railway station
Homestead
Aerodrome or landing ground

GEOPHYSICAL LEGEND

Zonal boundary
Intrazonal boundary
Possible diapiric structures
2000 Basement depth estimate
2000 Basement depth contour

Based on H54/80-4
Based on H54/81-25

LOCATION DIAGRAM




INDEX TO ADJOINING SHEETS

| | | |
|---|---|---|
| ANDAMOOKA | COPLEY | FROME |
| TORRENS | PARACHILNA | CURNAMONA |
| PORT AUGUSTA | ORROROO | OLARY |

AIRBORNE SURVEY, ORROROO – PARACHILNA, SA 1965

# MAGNETIC INTERPRETATION AND GEOLOGY

MILES 5 0 5 10 15 20 MILES

KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. H54/B1-33
TO ACCOMPANY RECORD No. 1966/126.