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RECORD NO. 1968/51

Musgrave Block Airborne Magnetic and Radiometric Survey, South Australia 1967

by

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SUMMARY

An aeromagnetic and radiometric survey of the eastern portion of the South Australian section of the Musgrave Block, was flown by the Bureau of Mineral Resources from July to October 1967. The main purposes of the survey were to assist geological mapping of the region and to define areas where rocks of the Giles Complex approach the surface.

Interpretation of the data is primarily qualitative; geological strikes and the boundaries of major rock units have been interpreted by delineating magnetic trends, subdividing the area into zones of specified magnetic character, and assessing the significance of these zones with reference to mapped geology. Regional structure has been interpreted from a study of anomaly configuration.

Correlation between the magnetic data and geology is generally fair. The magnetic results for the eastern third of the region have been interpreted as reflecting variations in the magnetic properties of basement rocks which dip eastwards under the sediments of the Great Artesian Basin.

Six fold axes and five faults have been defined which require confirmation by further mapping. The rocks of the Giles Complex do not exhibit any distinctive magnetic properties, and it is only possible to recommend broad areas of search for this suite.

In general the radiometric data show moderate correlation with current geological mapping. Forty radiometric anomalies satisfying the point-source criteria were detected, of which twelve are recommended for further investigation.

1. INTRODUCTION

An airborne magnetic and radiometric survey was flown by the Bureau of Mineral Resources, Geology and Geophysics in the ALBERGA and parts of the WOODROFFE, ABMINGA, LINDSAY, EVERARD, and WINTINNA 1:250,000 map areas (Plate 1) of the south-east Musgrave Block, South Australia, during the period July to October 1967. This work was requested by the Department of Mines, South Australia, in 1966 to assist geological mapping and to locate areas where potentially mineraliferous rocks of the Giles Complex occur at shallow depths.

The area covered by the survey comprises gently sloping plains at approximate elevations of 2000 feet above sea level in the north-west, 1500 feet above sea level in the south and 800 feet above sea level in the east. Topographic relief is greatest in the east-west trending Musgrave Ranges in the north-west quadrant of the survey area (Mount Woodroffe 4723 feet above sea level). The tor-like Everard Ranges (up to 3010 feet above sea level) form the only other major topographic feature in the region.

Pioneer geological work was carried out in the region by Streich (1893), Basedow (1905), and Jack (1915), but it was Wilson (1947 & 1960) who made the first modern study of the metamorphic and igneous rocks of the eastern Musgrave Ranges. Systematic mapping by the Geological Survey of the South Australia Mines Department was commenced in 1953. Several 1-mile geological sheets were published in 1955 and 1956, and the ALBERGA 4-mile sheet was published in 1959. Regional mapping was resumed in 1960, culminating in the publication of the MANN and WOODROFFE 1:250,000 scale sheets (Major et, al, 1967). Mapping is near completion on BIRKSGATE and LINDSAY and is in progress on EVERARD.

Previous geophysical work within the survey area includes an aeromagnetic survey flown by Aero Service Corporation for Delhi Australia Pty Ltd eastwards from longitude 134°00' (Delhi Australian Petroleum, 1962) and gravity and magnetic traverses made by the Department of Mines, South Australia (Knapman, 1953). Both of these surveys were designed to provide structural information on the basement of the Great Artesian Basin in relation to overlying sediments.

Additional geophysical work in adjoining areas includes aeromagnetic surveys flown by the BMR in the Amadeus Basin to the north (Young and Shelley, 1966) and in MANN and WOODROFFE to the west (Wells, 1962; Tipper, 1967).

Elves (1955) concluded, from airborne and ground magnetic surveys elsewhere in the Musgrave Block, that the gneisses, granulites, and granitic rocks, i.e. the siliceous rock types, tend to correspond to high regional magnetic levels on which many small anomalies are superimposed. He also found that norite, anorthosite, and serpentinite associated with the Giles Complex are frequently strongly magnetic.

The regional gravity survey by the Mines Department and low-level aeromagnetic survey by the BMR in MANN and WOODROFFE have been summarised by Rowan (1967). Data indicate that a gravity ridge extends far into Western Australia. A fault system (Median Belt) associated with this gravity ridge is a major crustal structural feature (Thomson, 1966), which extends across South Australia to the Broken Hill area in New South Wales.

The following chapter on geology consists of extracts taken from a report provided by the Department of Mines, South Australia (Thomson, 1967) written specifically for the BMR survey. This information and other assistance given by the Department of Mines staff are gratefully acknowledged.

2. GEOLOGY

The survey area covers part of the Musgrave Block, which comprises a mobile Precambrian core flanked to the north by the Amadeus Basin, to the south by the Officer Basin, and to the east by the Great Artesian Basin. The stratigraphic succession within this area consists of crystalline basement, probably of Lower Proterozoic to early Carpentarian age, overlain unconformably by (?) late Carpentarian, Adelaidean, Ordovician, Mesozoic, and Tertiary sediments. The only known post-basement igneous rocks are Adelaidean (Sturtian) basalts. Plate 5 shows the known geology.

Crystalline basement

These rocks are of the older Precambrian. They largely comprise metasedimentary gneisses and granulites of the Musgrave-Mann Metamorphics with instrusive granitic rocks (Coats, 1963; Major, 1966). Some of the latter are anatectic equivalents of the metasediments. In the Musgrave Ranges, basic granulites locally occur which probably represent metamorphosed basic igneous layered intrusive or extrusive rocks. Metamorphic grade is of the granulite facies, in and immediately south of the Musgrave Ranges, but declines generally to amphibolite facies to the south and north.

Traces of sedimentary iron formations are known in the western part of WOODROFFE outside the survey area.

In the vicinity of the Woodroffe Thrust, Ayliffe Hill, and Ferdinand Fault, the basement is intruded by norite which contains magnetite, minor pyroxenite, and anorthosite of the Giles Complex. The main zone of the Giles Complex extends west from the survey area across MANN into Western Australia (Sprigg and Wilson, 1959; Nesbitt and Talbot, 1966), and has been explored for nickel since 1953 (Thomson and Mirams, 1961; Miller, 1966).

Swarms of narrow dolerite, gabbro, and olivine-norite dykes are the youngest of the basement rocks. These are probably a late phase of the Giles Complex, emplaced in shears which trend northwest and northeast (Coats, 1963).

Carpentarian (?) sediments

The Moorilyanna Conglomerate in rectangles C4 and D4 and the Levenger Arkose in rectangles B1 and C1 constitute the rocks of this age. The sequence is commonly epidotised and is over 10,000 feet thick.

Adelaidean sediments

Sediments of Adelaidean age are established by the occurrence of Sturtian tillite near Chambers Bluff in the northeast of EVERARD (Coats, 1963). The apparently conformable underlying quartzite, dolomite, and shale sequence which rests unconformably on crystalline basement may be Willouran to early Sturtian in age. Basalt and a thin iron formation at the top of the tillite near Chambers Bluff extends east in to WINTINNA and possibly into the south-western part of ABMINGA. The overlying Adelaidean sequence is predominantly slate and shale and probably includes Tapley Hill Formation equivalents. These pass upwards into a slate, dolomite, and sandstone sequence below the unconformity with the Palaeozoic sediments.

Near Perndu Saltpan in LINDSAY, Mount Chandler Sandstone overlies, with possible unconformity, sandstones of assumed Adelaidean age (Krieg, 1966). The Adelaidean sediments show no evidence of pronounced regional metamorphism.

Lower Palaeozoic sediments

Possible Middle Cambrian sandstone and shale occur near Mount Johns south of Granite Downs Homestead (Krieg, 1966). The Mount Chandler Sandstone, of inferred Cambro-Ordovician age, is a persistent sandstone with conglomerate, siltstone, and dolomite members,which underlies a large part of the eastern Officer Basin and is exposed in the south of the survey area.

Post-Lower Palaeozoic sediments

Permian sediments probably underlie the Mesozoic sequence of the Great Artesian Basin in ABMINGA and WINTINNA but have not, to date, been established in the Officer Basin area. Mesozoic and Tertiary cover rocks occur in the east of the survey area; elsewhere, Quaternary cover predominates.

Structure

The dominant major fault and shear structures appear to strike WNW to NW, and it is postulated that the Musgrave Block is bounded by major shears and lineaments. Basement foliations in general trend north-east. The Mann Fault, of the Median Belt system (Thomson, 1966), is postulated to extend diagonally across ALBERGA and to produce local disturbance of foliation trends.

3. MAGNETIC RESULTS AND INTERPRETATION

The magnetic data are displayed in Plates 2 to 5. Plates 2 to 4 show all profiles of total magnetic intensity reduced to a north-south scale of 1:500,000 and related to a series of north-south lines which approximate the flight paths. East-west scales of 1:62,500 were used to improve data presentation.

For the reduction of the original profiles by pantography, the aircraft ground speed was considered constant along any one traverse. Departures from this constant speed introduce a positional error in the presentation of the data, which is manifested by a herring-bone pattern in the magnetic trends and zonal boundaries. The probable positional error, of $\pm \frac{1}{8}$ mile, is a function of the distance from the control latitudes 26°15' and 27°00' south.

Plate 5 shows every eighth profile together with geological mapping to facilitate correlation.

The interpretation of the magnetic data is shown in Plate 6. This interpretation is primarily qualitative and involves the delineation of magnetic trends and the subdivision of the area into zones of differing magnetic character. 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 limitations of this classification are discussed in Appendix 1 together with the techniques employed in the quantitative interpretation of the magnetic data.

<u>Magnetic zones and their significance</u>

Tabulated below are the zone types and a brief description of their magnetic character. The anomaly range quoted for each zone type includes most, but rarely all, of the anomalies in any zone of that type.

Zone type	Anomaly range (gammas)	Magnetic linearity
1	0-100	poor
2	100-200	poor
3	200-500	poor
4	greater than 500	poor
5	0-200	good
6	200-500	good
7	500-1000	good
8	greater than 1000	good

Zones of type 1 are interpreted as near-homogeneous acidic igneous masses or as sequences of non-magnetic sedimentary rock. Zones of types 2, 3, and 4 are interpreted as indicating successively greater basicity of the rocks, with the proviso as set out in Appendix 1.

Zones of types 5 and 6 are mainly attributed to interbedded sediments or sediment covered crystallines. These zones mainly occur in the eastern half of the survey area where the sediments of the Great Artesian Basin are exposed.

Zones of types 7 and 8 probably represent basic or ultra-basic intrusions (e.g. dykes) or structurally deformed basement rocks. The latter appears to be the more likely interpretation in areas where zones containing many trends are encountered.

In the western two-thirds of the survey area virtually the entire pattern of magnetic zones is interpreted as reflecting near-surface structural and lithological variations. Thus the distinction between zones of good and poor magnetic linearity which have similar anomaly ranges is equally likely to reflect changes in structure as in rock type, most anomalies being attributed to crystalline igneous and metamorphic rocks.

To the east, sediments of the Great Artesian Basin crop out, and the zonal pattern is interpreted as indicating the structure and lithology of basement rocks beneath a sedimentary cover.

<u>Comparison of zonal configuration, magnetic trends, and mapped geology (Plate 6)</u>

North of the Davenport Fault and the Ferdinand Fault, in the north-west corner of the survey area, the magnetic trends closely parallel the fault structures and surface foliations except between McNamara Hill and Michells Nob. The sources of these anomalies are interpreted as having a tectonic association with major faults in this region. Areas mapped as Giles Complex are mostly coincident with zones of type 6, 7, and 8, and it is recommended that particular attention should be paid to these zones during subsequent mapping. Along the Davenport and Ferdinand Faults zones of types 6, 7, and 8 may be due to mineralisation of the fault planes.

Immediately south of the Davenport Fault lies a region of zone-type 1, which is interpreted as an area of sedimentary rocks about the mapped position of the Mann Fault. The Levenger Arkose correlates with this zone south of the Mann Fault, and is therefore postulated to extend further north than mapped. Along the northern boundary of rectangle C1 the magnetic anomalies have too great an amplitude to be attributed to the Levenger Arkose. It is postulated that crystalline basement rocks occur at shallow depths at this location and to the south.

In rectangles D1 and E1 lies a region characterised by numerous magnetic trends. The zones of types 6, 7, and 8 which contain these trends have no definite geological correlation but are interpreted as one general rock type. These magnetic trends may be associated with structures such as faults and folds, but ground investigations are required to evaluate this interpretation. The region is flanked to the north, west, and south by zones of types 2, 3, and 4. No correlation of these zones with geology is at present possible, so their significance is unknown. The magnetic anomaly amplitudes in rectangles E1 and F1 decrease progressively to the south, and in the southeastern corner of F1 a region of zone-type 1 coincides with sediments of the Officer Basin. The gradation of anomaly amplitudes is attributed to the masking of basement magnetic character by an increasing thickness of sedimentary cover.

Zonal configurations and magnetic trends in a region included in D2, D3, E2, and E3 around the Everard Ranges are similar to those in D1 and E1 and also to those in the north-east corner of the survey area. Comparison of zone boundaries with the geology in D2, D3, E2, and E3 indicate a correlation of the zones of type 6, 7, and 8 with biotite adamellite and hornblende adamellite, which may also account for the anomalies in the other two regions. The extensive negative trend through D2 and D3 is interpreted as being due to a dyke emplacement along a fault.

Large zones of type 3 occur in the area bounded by the Ferdinand Fault, latitude 26°45', and the Alberga River. This region is similar to an area in E1 and F1, and is characterised by the inclusion of elongated east-west zones of types 6 and 7. The longest of these are interpreted as being due to mineralisation or intrusion along fault planes; however, no correlation of zones with geology is as yet possible. Numerous negative trends occur in the southern portion of this area, and are interpreted as being due to dykes.

The zone of type 1 in rectangle D4 closely follows the boundary of the Moorilyanna Conglomerate at its western end. This zone is therefore interpreted as Moorilyanna Conglomerate both in D4 and D5. The northern boundary of this rock unit is defined by a single trend, which has been attributed to a fault. In the southern portion of D4 a zone of type 2 coincides with an area mapped as undifferentiated crystalline basement rocks. Radiometric data (see Chapter 4) supports the interpretation of this zone as an area of non-magnetic granite.

The region of zone-type 1 to the south in E4 and E5 correlates with mapped Tertiary and Mesozoic basin sediments, Mount Chandler Sandstone, and Adelaidean slates, shales, and tillites. The zone of type 7 in E5 which overlaps the Adelaidean rocks may be due to basalts or iron formations, which are shown nearby.

The zonal configuration and direction of trend lines in the north-east corner of the survey area have already been compared to those in D2, D3, E2, and E3. The decrease in density of these trends coupled with the broadening of anomaly form and decrease in anomaly amplitude to the east indicate a thickening of sedimentary cover over a crystalline basement. Depth determinations indicate that the crystalline basement progressively deepens eastward into the Great Artesian Basin, from about 400 feet below ground level at longitude 133°55' to 1100 feet at 134°05' and to 1800 feet at 134°25'.

The magnetic anomalies in D5, E5, and E6 are again attributed to the crystalline basement, which is interpreted to be within 1000 feet of surface level and to dip at low angle to the east. The lack of geological control precludes the correlation of zones in this region with any specific rock type.

Structure

Interpreted dykes, fold axes and faults are shown in Plate 5 together with known geological structure.

Dykes. Of the many dolerite dykes shown on the geological map, few produced resolvable magnetic anomalies at the survey altitude. There is no correlation between geology and negative magnetic trends, which are however interpreted as remanently magnetised dykes. These dykes are interpreted as a single suite owing to their consistency of east-west trend and remanent magnetisation.

The extensive positive trends may be interpreted as being due to other dyke suites. It is, however, more likely that they represent mineralisation along faults. As the geological correlation is poor the rock type comprising the dykes cannot be determined.

Fold axes. Delineation of fold axes is based on the convergence of magnetic trends coupled with the axial symmetry of zones, but is at best tentative. No attempt has been made to define the type of folding, and the main relevance of the interpreted fold axes is as a guide to further mapping. In all, six fold axes have been postulated, all of which strike approximately east-west, which indicates that they may be contemporary with the major east-west faults in the survey area. It is of interest to note that in D2 and E2, three of the fold axes are coincident with negative trends.

Faults. Correlation between mapped and interpreted faults is fair, the known faults generally corresponding to alignments of zones of type 5,6,7, and 8. The Davenport Fault in B1 shows good correlation with a positive trend, and the magnetic profiles show a sharp discontinuity at the fault line. On the other hand the magnetic evidence for the Mann Fault to the south is poor, there being no correlatable magnetic trend over most of its mapped length. The Woodroffe Thrust coincides with positive trends in the south-west, but at its north-eastern extremity the only indication of its presence is given by a change in zone type from 2 to 3. This may indicate either more basic rocks or shallower sedimentary cover to the south-east. An intermittent line of positive magnetic anomalies is associated with the Ferdinand Fault, which runs north-east through B2 and A3. There is no magnetic evidence for an east-west offshoot of this fault in A3. Similarly there is no magnetic evidence for a fault at the eastern boundary of the Levenger Arkose in C1.

The Indulkana Fault in D4 is evidenced by a change in zones from type 1 to type 2; however, the Indulkana shear zone does not appear to have any associated magnetic character, and even crosses several magnetic trends without displacing them.

Four east-west faults have been interpreted: from C2 through to C5; in C2 to coincide with a line of positive anomalies; from D2 to D3 to coincide with a line of negative anomalies; and from D4 to D6 to coincide with a sharp discontinuity in the magnetic profiles.

An important fault has been postulated to extend from A1 to E2 across the survey area, for which the following evidence has been found:

(1) In A1, A2, B1, and B2 the magnetic trends swing abruptly from south of east to north-east along a distinct line.

(2) The Mann Fault, Davenport Fault, and Woodroffe Thrust are geologically and magnetically clearly defined to the west of this line. Only the Mann Fault has a postulated geological extension to the east, which the magnetic evidence, however, does not support.

(3) Over the length of the postulated fault there is an almost total discontinuity of magnetic trends.

(4) The proposed east-west faults in C2 and D2 show no continuity west of this line.

(5) The trended region in D1 and E1 is similar to that in D2, D3, E2, and E3. It is possible to match up the zone types and two fold axes on either side of the proposed fault by displacing the western region by 10 miles southwards.

(6) The geological map shows surface foliations and a short fault line close to the proposed fault in A1 and B1, and south-south-east trending dolerite dykes in EVERARD.

(7) Trends that parallel this postulated fault are apparent immediately to the north on the AYERS ROCK aeromagnetic map (Young and Shelley, 1966).

(8) There is a flexure in the magnetic basement contours of the Officer Basin indicating a southern movement east of the proposed fault of about six miles (Exoil Pty Ltd, 1965).

(9) The Officer River runs along the line of the fault in C1 and D2.

The scarcity of geological evidence to support the presence of this postulated fault is the most serious argument against the interpretation. No magnetic anomaly has been found along the proposed fault, but this is not surprising owing to the orientation of the flight lines. If this fault is confirmed by subsequent geological mapping, it is probable that the proposed fault belt from C2 through C5 is the extension of the Mann Fault system. This interpretation is supported by the postulated distribution in the survey area of the Carpentarian rocks, whose sedimentation was probably fault controlled (Coats, 1962). It is further postulated that the Moorilyanna Conglomerate in C4 is located in a graben structure. The presence of a negative gravity anomaly between De Rose Hill and Granite Downs Homesteads (Knapman, 1953) supports this interpretation.

4. RADIOMETRIC RESULTS AND INTERPRETATION

Radiometric data were recorded by two scintillometers, each adjusted for a specific purpose. The inboard scintillometer, set with a 10-second time constant, was used to record broad fluctuations of radiometric intensity across the area to assist geological mapping. The outboard scintillometer, set with a 1-second time constant, was used to detect localised sources of radioactivity.

Inboard scintillometer

A contour representation of the radiometric data, superimposed on mapped geology, is shown in Plate 7. Some smoothing of the contours was necessary to minimise contour distortions introduced 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; variations in instrument sensitivity; and positional error identical to that of the magnetic data. The main factors governing the radiometric count displayed are rock radioactivity, variations in ground clearance, and thickness of soil cover.

The contour pattern in the north-west corner of the survey area is considerably affected by extreme topographic relief. However, the 'low' extending east-west through B1 is not directly associated with greater ground clearance so probably reflects a genuine variation in radioactivity. Thus it is interpreted that the 'highs' in A1, A2, and B2 are produced by outcropping granitic rocks whereas the 'lows' may be associated with more basic rocks of the Giles Complex.

The radiometric 'high' along the boundary of B1 and C1 corresponds well to zones of type 5, 6, and 7 interpreted from the magnetic data. It thus corroborates the evidence for very shallow crystalline basement in the region.

Of the three 'highs' in D1 and E1 the southernmost can be correlated with an outcrop of granitic rock, and it appears likely that the other two have a similar origin. The general trend of 'highs' along the Officer River is interpreted to be due to the deposition of slightly radioactive alluvium by the drainage system.

The alignment of radiometric 'lows' along the Ferdinand Fault coincides with the alignment of magnetic zones of types 6, 7, and 8. Although the significance of these 'lows' cannot be determined without ground observations it is probable that they are produced by either a basic dyke or leaching along the fault zone.

The central portion of the survey, south of the Ferdinand Fault but north of latitude 26°50', can be divided into two regions. The south-west region displays a background count of 25-50 counts per second, which is similar to the background on the other side of the Officer River. These low values probably reflect soil cover rather than underlying geology. The north-east region displays a more complex pattern, with anomalies rising to 125 c.p.s. in places. The uniformity of magnetic character over both regions suggests that the radiometric 'highs' in A3, A4, B3, and B4 are due to radioactive alluvium derived from biotite adamellite and hornblende adamellite in the vicinity of the Ferdinand Fault. The Everard Ranges region (E2 and E3) displays a series of 'highs' of up to 150 c.p.s. which is similar to a smaller region of 'highs' near Moorilynanna Hill in D4. Both these regions correlate closely with mapped biotite adamellite and hornblende adamellite. These two regions are separated by a 'low' of 25 to 50 c.p.s., which probably reflects the alluvial cover since there is no similar break in the magnetic zones.

In D4 and E4, extremely good correlation is observed between the radiometric contours and the mapped geology. West of Granite Downs Homestead, anomalies rise to 150 c.p.s. above base level, and the 75-c.p.s. contour in this region closely follows the magnetically interpreted boundary of undifferentiated crystalline rocks. These rocks were mapped as zone-type 2 in the magnetic interpretation and thus display all the characteristics of a granite. The radiometric 'low' which runs north-south across this region coincides with a valley and thus is almost certainly of topographic origin.

South of this region two areas mapped as Mount Chandler Sandstone show very good correlation with radiometric 'lows' of 0 to 25 c.p.s. These 'lows' occur in upland areas with presumably little soil cover, and thus represent ideal conditions for radiometric interpretation. The ribbon of Mount Chandler Sandstone around the Officer Basin shows little correlation with radiometric 'lows' over most of its length, possibly because of its narrowness.

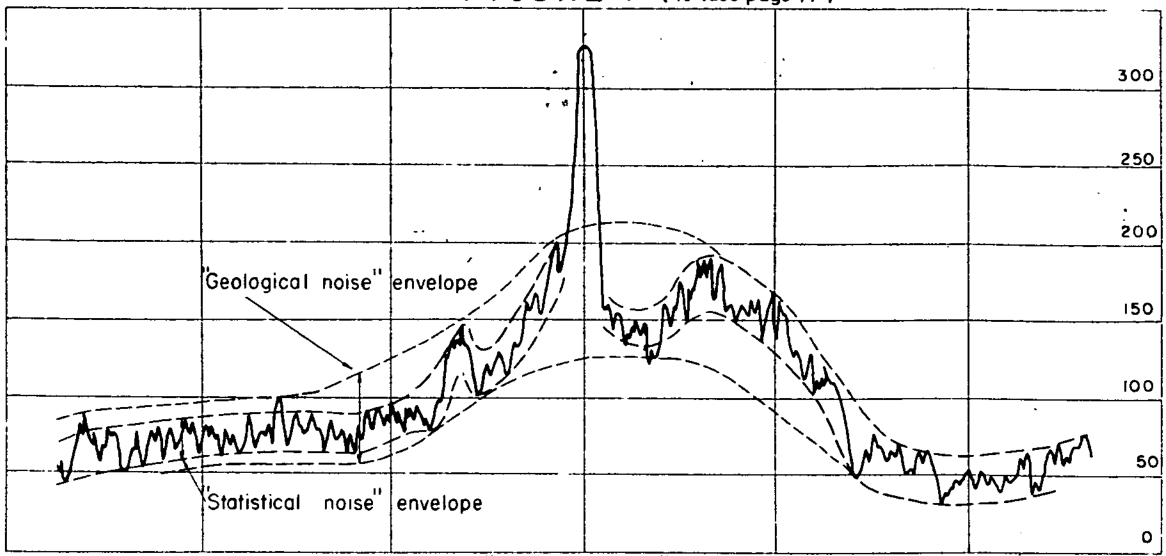
Rectangle A5 contains a series of 'highs' rising over 175 c.p.s. which indicate good outcrops of a fairly radioactive rock. Plates 5 and 6 show that this region and that over the Everard Ranges have similar magnetic and radiometric character. The anomalies over the Everard Ranges are attributed to biotite adamellite and hornblende adamellite rock, which is therefore interpreted to constitute crystalline basement in both regions.

The eastern quarter of the survey area displays little radiometric character, and few anomalies rise above 50 c.p.s. This is consistent with sediments of the Great Artesian Basin overlying crystalline basement. Radiometric results indicate that a tongue of sediments extends westwards into C5.

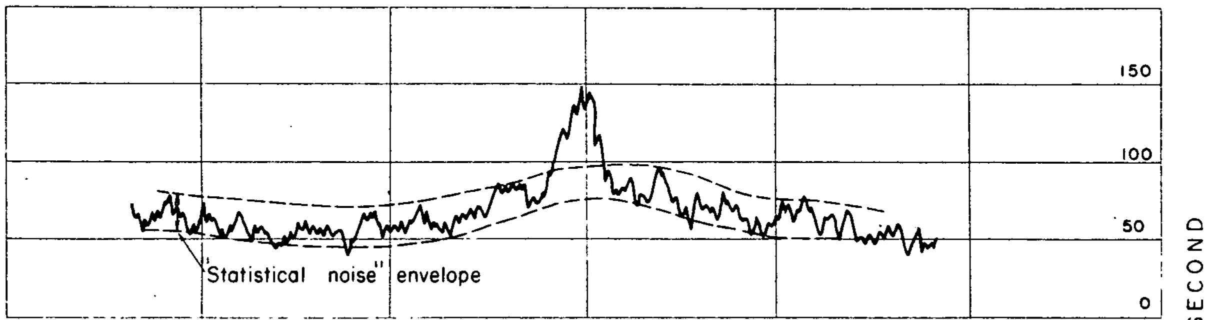
Outboard scintillometer

Forty anomalies from restricted sources are listed in Appendix 2 and are shown in Plate 7. The criteria used in selecting

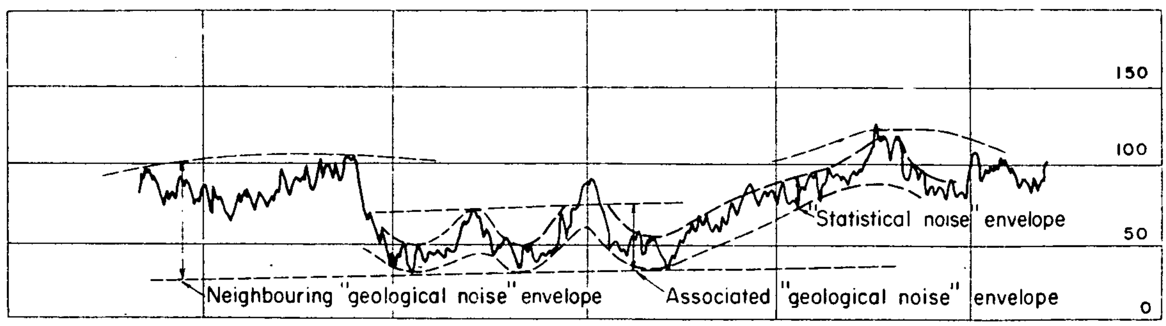
FIGURE 1 (To face page 11)



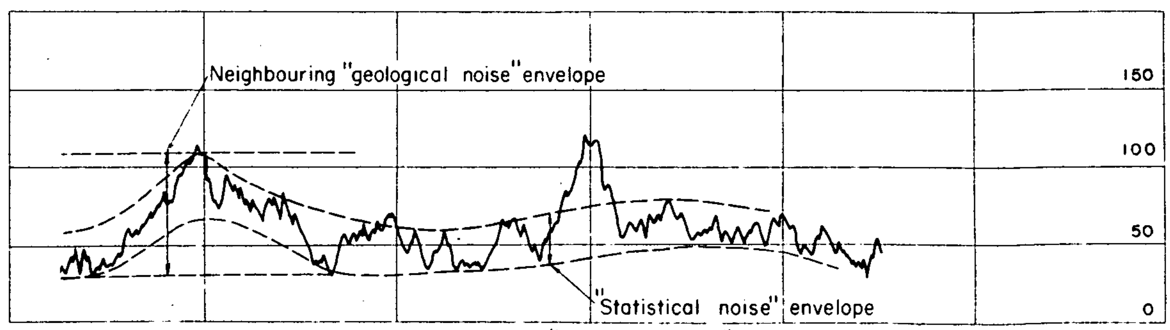
A Anomaly significant with respect to "geological noise" envelope.



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

these anomalies are discussed in Appendix 1. The anomalies are classified into four categories, A, B, C, and D, examples of which are illustrated in Figure 1. Only anomalies of types A and B are recommended for ground investigation as those of types C and D might prove very difficult to detect by ground work and their significance is marginal.

Some of the anomalies of types A and B do not warrant ground investigation. These include: Nos. 4, 5, and 6, which lie in the Musgrave Ranges and are probably related to topography; Nos.16 and 30, which lie in the Great Artesian Basin and are near creeks; and Nos. 24, 28, and 37 which are believed to be due to isolated outcrops of local rock.

In areas of crystalline basement outcrop, anomalies Nos. 8, 9, 10, 20, 21, 22, 23, 38, 39, and 40 do not appear to be associated with any known geological or topgraphic features and are recommended for ground investigation. In areas of basin sediment, anomalies 14 and 18 are also worthy of ground investigation as they do not appear to be associated with the drainage patterns.

5. CONCLUSIONS AND RECOMMENDATIONS

In general no close correlation exists between geological data and magnetic zones in areas of shallow crystalline basement. Magnetic data do however indicate areas of similar crystalline basement rocks. It is recommended that Plate 6 be used extensively in the subsequent mapping of the area. Trends and zones should be used to extrapolate observed zone-type/lithology correlations into areas where soil cover hampers ground investigations. The interpreted folds, faults, and dykes require examination in detail. The postulated north-south fault in the west of the survey area is a major tectonic feature. It is interpreted as a dextral fault with a displacement of approximately ten miles.

The postulated extensions of the Mann and Davenport Faults are also displaced southwards. They are worthy of investigation for an association with the Giles Complex, as are zones of types 6, 7, and 8 in the north-west corner of the survey area. A graben structure has been postulated in the south-west of ABMINGA. Dykes of at least two intrusive suites appear to be present in the survey area. Some of these probably intrude fault lines.

The radiometric data complement the magnetic data in several regions, notably in that to the south of Granite Downs Homestead. Topographic and drainage features have been discounted as far as possible.

Forty radiometric anomalies satisfying the point-source criteria were detected. Their significance will be determined only by ground investigation; however, of these only twelve are considered worthy of inspection.

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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 is defined as the line joining the peak positions of anomalies, and is broadly interpreted as indicating continuity of a geological feature over the length of the trend. Thus it may represent a marker horizon, a structure within a mineralogically homogeneous rock, or in some instances a topographic feature. Except for perfectly symmetrical anomalies, however, a trend will not be coincident 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 dominant anomaly amplitude range. Although these criteria are generally satisfactory for distinguishing between contrasting rock types, they do introduce limitations to zonal significance when the zones are derived from profile data only. 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 differentiate between the two cases. Recognition of anomaly trends, however, requires a reasonably large angle between the flight-path direction and the geological strike; thus a type-3 zone could in fact represent a regular interbedded sequence striking near-parallel to the flight paths. Magnetic trends are also difficult to delineate when two or more strike directions are represented in the one region.

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 more accurately to equate zones and lithology, the zones would need to be based on susceptibility values calculated for each anomaly.

Where considerable thickness of non-magnetic sediments overlie the magnetic basement rocks, zone boundaries have less significance. In such areas suitable anomalies are analysed to provide an estimate of the thickness of those sediments.

Certain structural features have been qualitatively interpreted from the magnetic results. Faults were interpreted from the colinear termination of magnetic zones and trends, by abrupt changes in trend direction, and by comparison of magnetic anomalies with those over known faults. Where a folded sequence contains one or more magnetic horizon, the fold has been interpreted from a repetition of zones and/or individual anomalies.

Negative trends, if they extend for several miles, are attributed to igneous basic intrusions since they are mainly caused by remanant magnetisation at these latitudes.

Quantitative magnetic interpretation

Quantitative interpretation involved the determination of depths of selected anomalies. Depths of magnetic bodies were obtained by several methods. With anomalies of simple form, depths were rapidly calculated using the half-maximum-slope method devised by Peters (1949); for more complex anomalies, the curve-matching technique of Gay (1963) was used.

Interpretation of outboard radiometric data

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

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

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

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

2. 'Geological noise' is a variation of the gamma-ray intensity from a heterogeneous source which is often simulated by variations in overburden above a homogeneous source.

The envelopes containing each form of background noise have a height of four times the standard deviation of that noise.

Examples of anomalies of different categories are shown in Figure 1.

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

$$3 \text{ seconds} \leqslant W \leqslant 4 \text{ seconds}$$

This width criterion results in the acceptance of a continuous series of sources, limited by those of 300-ft radius centred on the flight path, and point sources located 300 ft from the flight path.

APPENDIX 2

OUTBOARD RADIOMETRIC ANOMALIES

Anomaly number	Line number	Fiducial number	Half-peak width (secs)	Amplitude x S.D.	Class-ification
1	10S	0420.0	4.0	6	C
2	17N	0962.0	3.5	5	D
3	20S	1600.0	4.0	6	D
4	25S	0375.5	3.5	9	A
5	31N	1401.5	3.5	12	A
6	35N	0769.0	3.5	4	B
7	44S	0737.0	4.0	8	C
8	84N	0080.0	3.5	10	A
9	103S	0301.0	4.0	5	A
10	140N	1593.0	3.5	6	A
11	141S	1211.0	4.0	4	C
12	144N	1581.0	3.5	3	D
13	182N	1625.5	4.0	4	D
14	178N	0133.0	4.0	6	B
15	164N	1552.0	3.5	5	D
16	157S	1044.0	3.5	5	B
17	131N	1104.0	3.5	5	D
18	126S	0306.5	3.5	6	A
19	98N	1507.0	4.0	5	C
20	75S	0318.5	3.5	5	A
21	41N	1490.0	3.5	10	A
22	31N	1296.0	3.5	12	A
23	74N	0535.5	3.5	5	A
24	71S	1261.5	4.0	12	A
25	84N	0177.5	3.5	5	C
26	91N	0565.5	3.5	7	D
27	107S	0386.5	4.0	7	D
28	118S	0415.0	3.5	5	A
29	137N	1524.5	3.5	6	C
30	185S	0945.5	4.0	4	A
31	181S	1939.0	4.0	6	D
32	134S	0432.0	3.5	5	C
33	136S	1449.0	3.5	5	C
34	130S	1383.0	3.5	5	D
35	69S	1704.5	3.5	4	C
36	47N	0090.0	4.0	8	C
37	41N	1418.0	4.0	13	A
38	5S	1577.0	3.5	7	A
39	16S	0684.0	4.0	20	A
40	22S	1526.5	4.0	7	B

APPENDIX 3

OPERATIONAL DETAILS

Staff

Party Leader	:	P. Browne-Cooper
Geophysicist	:	D. Waller
Senior Radio Technician	:	J. Swords
Drafting Assistant	:	P. Kersulis
Geophysical Assistants	:	K.A. Mort D. Park
Pilots	:	Captain L. Giddens First Officer J. Linsday
Aircraft Maintenance Engineers.	:	B. Hall P. Derrick R. Allen

(Pilots and Aircraft Maintenance Engineers: T.A.A.)

Equipment

Aircraft	:	DC 3 VH-MIN
Magnetometers	:	MFS-5 saturable core fluxgate, tail boom installation coupled to "Speedomax" and digital recorders. MFD-4 saturable core fluxgate ground installation for storm warning, coupled to Esterline - Angus recorder.
Scintillographs	:	Twin crystal MEL scintillation detector heads inboard and single phosphor detector head outboard (the latter suspended from a cable 200 feet below aircraft.) Outputs coupled to De Var recorder.
Radio Altimeter	:	STR 30B, frequency modulated, output coupled to De Var recorder.
Barometric Altimeter	:	Pilot control
Air Position Indicator	:	Track recorded by De Var recorder
Camera	:	BMR 35-mm strip

Survey specifications

Line Spacing	:	1 mile throughout
Line Orientation	:	North-South
Tie System	:	Single and double lines, spaced 15 miles apart.
Altitude	:	500 feet above ground level
Navigation Control	:	Aerial photographs
Record Sensitivity		
MFS-5	:	50 gammas/inch or 100 gammas/inch.
MFD-4	:	40 gammas/inch
Inboard Scintillograph	:	25 c.p.s./inch
Outboard Scintillograph	:	25 c.p.s./inch
Scintillometer Time Constants	:	Inboard 10 seconds
	:	Outboard 1 second

APPENDIX 4

SUSCEPTIBILITIES OF ROCK SAMPLES

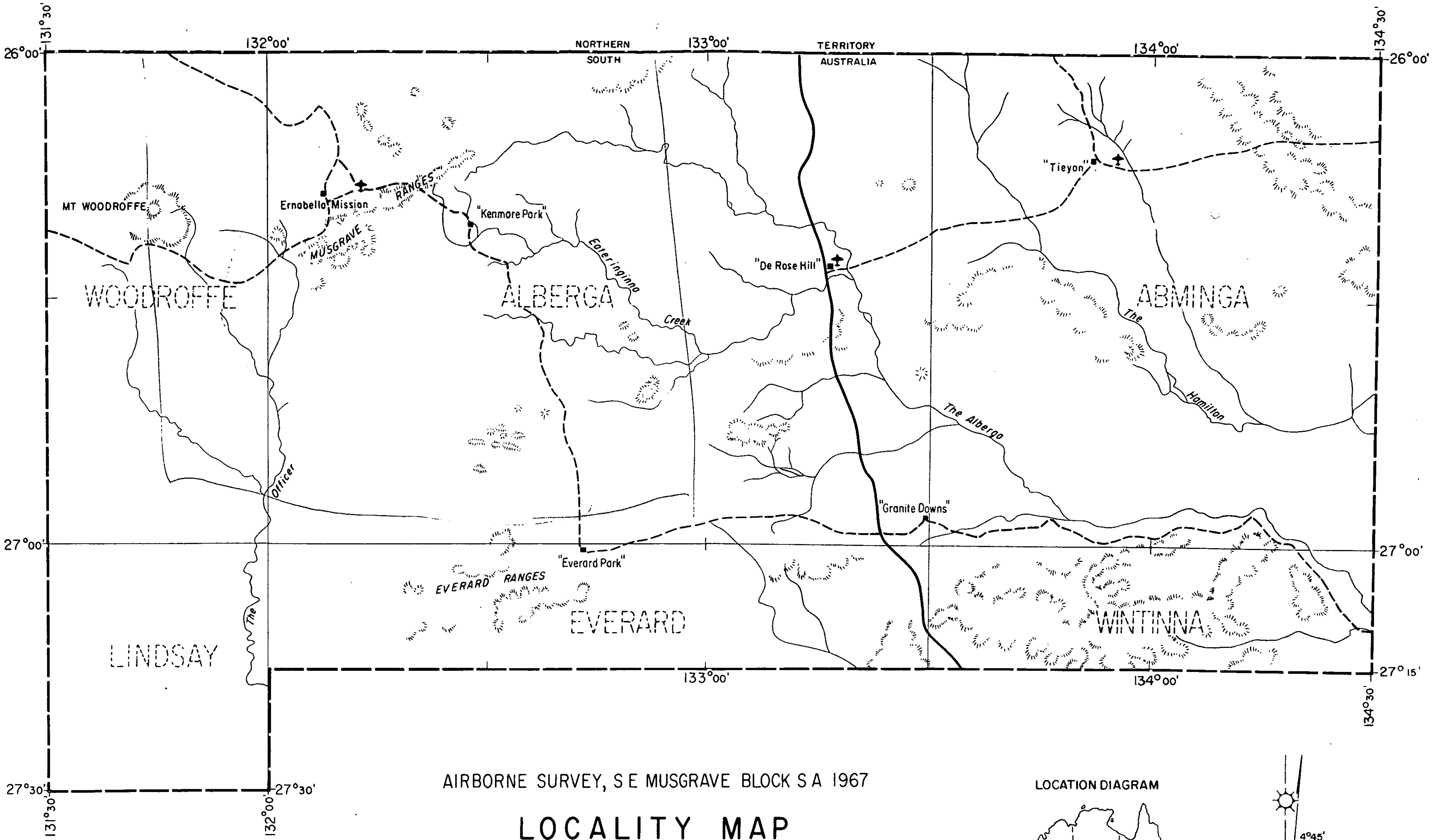
Laboratory No.	1:250,000 map area	Grid position	Geological description	Susceptibility (10^{-3} CGS)
67/484	Everard	27°00' S 132°43' E	Granite	0.18
67/485	Alberga	26°42' S 132°22' E	Goethite	0.015
67/486	Alberga	26°42' S 132°22' E	Micro gabbro	0.52
67/487	Alberga	26°42' S 132°22' E	Granite (weathered)	Very low
67/488	Alberga	26°27' S 132°27' E	Charnockite	0.28
67/489	Alberga	26°24' S 132°28' E	Acid granite	0.08
67/490	Alberga	26°18' S 132°26' E	Acid granite	0.26
67/491	Alberga	26°16' S 132°18' E	Biotite granite	0.32
67/492	Alberga	26°17' S 132°08' E	Ernabella adamellite	0.56
67/493	Woodroffe	26°19' S 131°50' E	Norite	0.48
67/494	Woodroffe	26°17' S 131°45' E	Quartz-felspar-biotite Garnet gneiss	0.05
67/495	Woodroffe	26°23' S 131°45' E	Granulites	0.04

The rock samples were provided by the Department of Mines, South Australia, and the susceptibilities were measured in the BMR Laboratory.

APPENDIX 5

ADDITIONAL GEOLOGICAL MAPS AVAILABLE FOR THE SURVEY AREA FROM THE DEPARTMENT OF MINES, SOUTH AUSTRALIA

Plan No.	Title	Scale
67-443	Regional Geological Map of Musgrave Block, S. Australia	1:1,000,000
67-444	WOODROFFE, Generalised Geological Map	1:250,000
67-445	ALBERGA, Generalised Geological Map	1" = 4 miles
67-446	ABMINGA, Generalised Geological Map	1:250,000
67-447	LINDSAY, Generalised Geological Map	1:250,000
67-448	EVERARD, Generalised Geological Map	1:250,000
67-449	WINTINNA, Generalised Geological Map	1:250,000

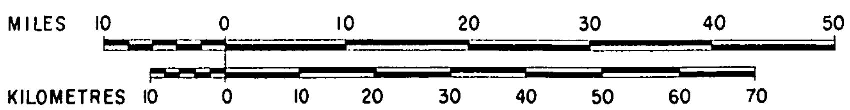


AIRBORNE SURVEY, S E MUSGRAVE BLOCK S A 1967

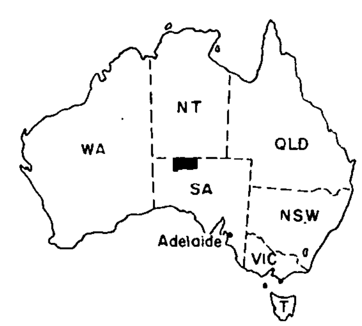
LOCALITY MAP

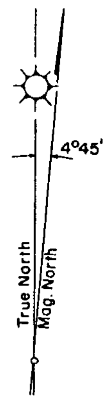
INDEX TO ADJOINING SHEETS

AYERS ROCK	KULGERA	FINKE
WOODROFFE	ALBERGA	ABMINGA
LINDSAY	EVERARD	WINTINNA



LOCATION DIAGRAM





TO ACCOMPANY RECORD No. 1968/51

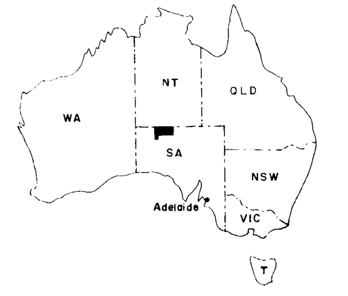
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G53/B1-37

PLATE 2

APPROX. PROFILE SCALE

2000 1000 0 GAMMAS

LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

AYERS ROCK	KULGERA.	FINKE
WOODROFFE 1	ALBERGA 2	ABMINGA 3
LINDSAY	EVERARD	WINTINNA

AIRBORNE SURVEY, SE MUSGRAVE BLOCK, SA 1967

TOTAL MAGNETIC INTENSITY PROFILES

SHEET 1

NORTH-SOUTH SCALE

MILES 10 0 10 20 30 40 MILES

KILOMETRES 10 0 10 20 30 40 50 60 KILOMETRES

EAST-WEST SCALE

MILES 1 0 1 2 3 4 5 MILES

KILOMETRES 1 0 1 2 3 4 5 6 7 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 ±½ MILE.

THE SOUTH COMPONENT OF THE REGIONAL GRADIENT IN TOTAL MAGNETIC INTENSITY HAS BEEN REMOVED FROM EACH PROFILE BY ROTATION ABOUT THE POINT WHERE THE PROFILE INTERSECTS THE NORTHERN SURVEY BOUNDARY. THIS COMPONENT AMOUNTS TO 9·0 GAMMAS PER MILE.

TO ACCOMPANY RECORD No. 1968/51

G 53/B1-39

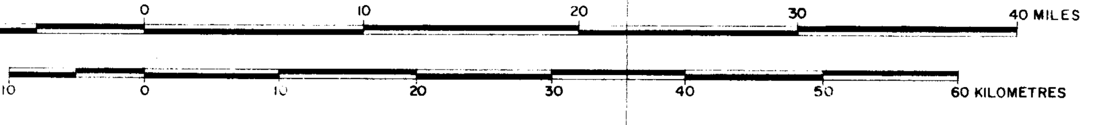
PLATE 3

AIRBORNE SURVEY, SE MUSGRAVE BLOCK, SA 1967

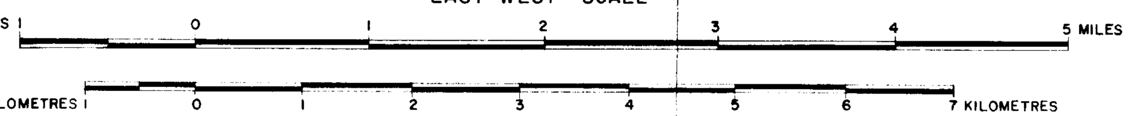
TOTAL MAGNETIC INTENSITY PROFILES

SHEET 2

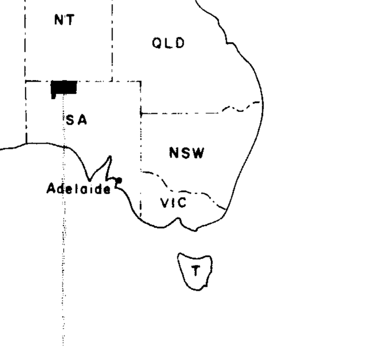
NORTH-SOUTH SCALE



EAST-WEST SCALE

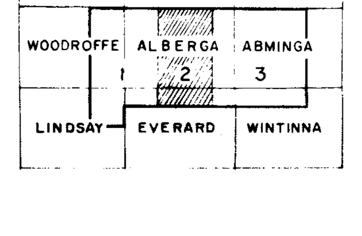


LOCATION DIAGRAM



APPROX. PROFILE SCALE

INDEX TO ADJOINING SHEETS



EXPLANATORY NOTES

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EXTRAPOLATED PORTIONS OF THE PROFILES ARE DOTTED.

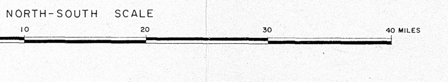
G 53/B1-40

AIRBORNE SURVEY, SE MUSGRAVE BLOCK, SA 1967

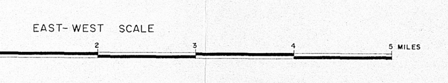
TOTAL MAGNETIC INTENSITY PROFILES

SHEET 3

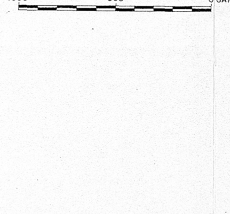
NORTH-SOUTH SCALE



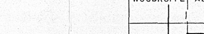
EAST-WEST SCALE



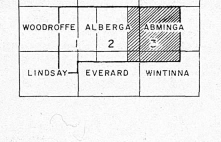
LOCATION DIAGRAM



APPROX. PROFILE SCALE



INDEX TO ADJOINING SHEETS



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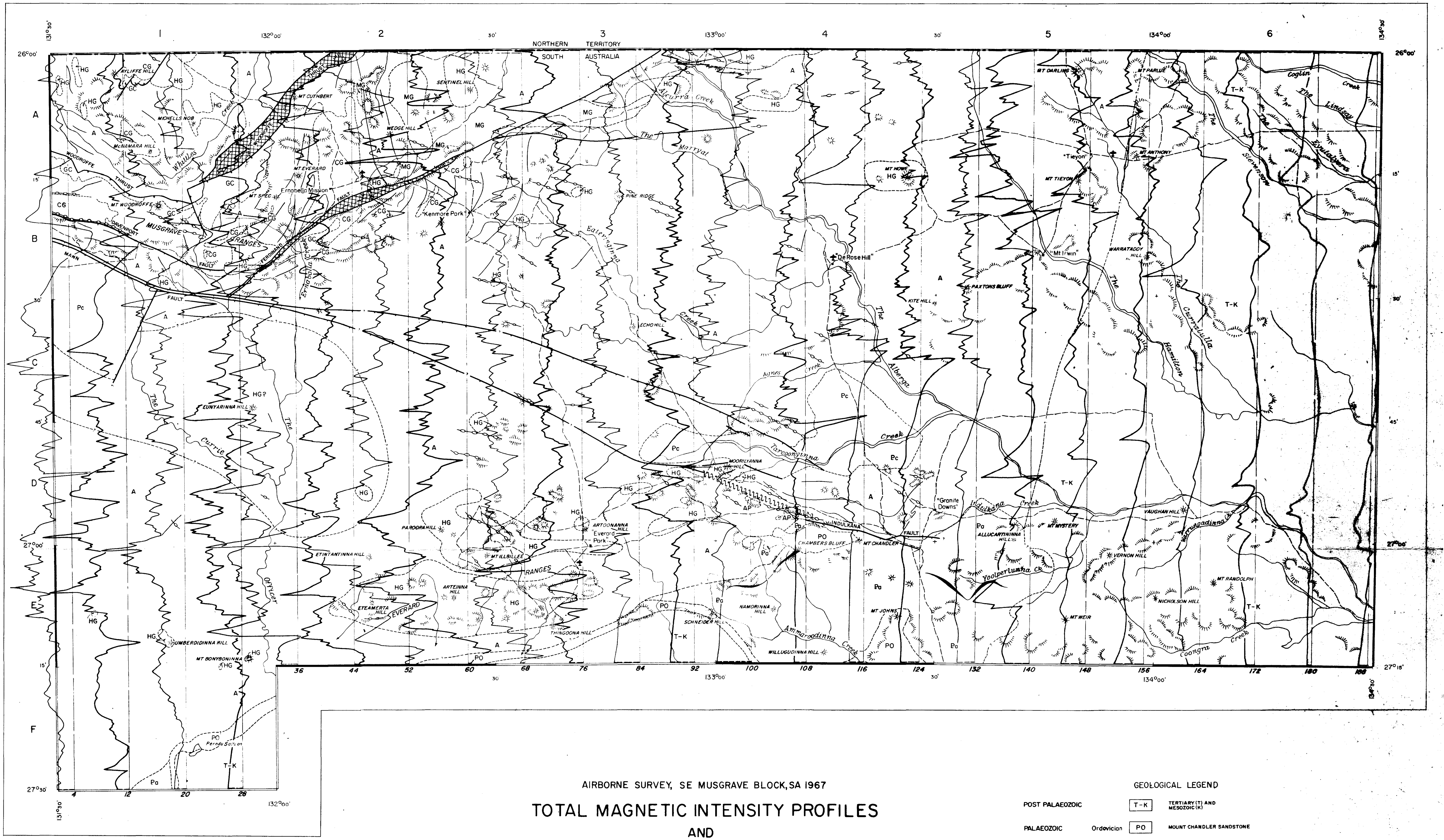
EXTRAPOLATED PORTIONS OF THE PROFILES ARE DOTTED.

TO ACCOMPANY RECORD No. 1968/51

G 53/B1-41

PLATE 5



AIRBORNE SURVEY, SE MUSGRAVE BLOCK, SA 1967

TOTAL MAGNETIC INTENSITY PROFILES AND GEOLOGY

MILES 10 0 10 20 30 40 MILES

KILOMETRES 0 0 10 20 30 40 50 60 KILOMETRES

GEOLOGICAL LEGEND

POST PALAEOZOIC		T-K	TERTIARY (T) AND MESOZOIC (K)
PALAEOZOIC	Ordovician	PO	MOUNT CHANDLER SANDSTONE
PROTEROZOIC	Adelaidean	Pa	MAINLY SLATES, SHALES AND TILLITES BASALT AND/OR IRON FORMATION
	Carpentarian	Pc	LEVENGER ARKOSE AND MOORILYANNA CONGLOMERATE
OLDER PRECAMBRIAN	Crystalline Basement Rocks of Musgrave Block	A	UNDIFFERENTIATED CRYSTALLINE BASEMENT ROCKS
			DOLERITE DYKES
		GC	BASIC AND ULTRABASIC INTRUSIVES OF GILES COMPLEX
		MG	MICROADAMELLITE AND MICROGRANITE
		HG	BIOTITE ADAMELLITE AND HORNBLENDE ADAMELLITE
		CG	HYPERSTHENE ADAMELLITE
		AP	APLITE OF INDULKANA SHEAR ZONE
		HG?	UNDIFFERENTIATED GRANITE ROCKS

GEOLOGICAL BOUNDARY

FAULT

FAULT, STRIKE AND DIRECTION OF DIP

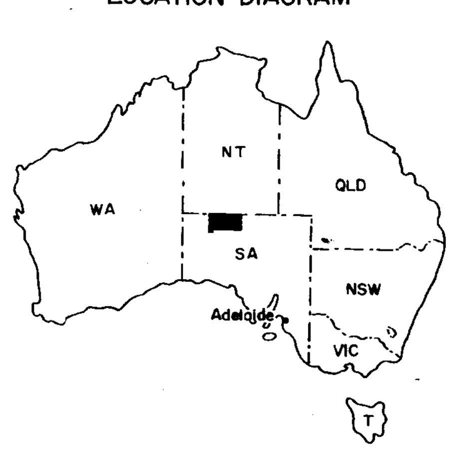
THRUST OR MAJOR SHEAR ZONE, STRIKE AND DIRECTION OF DIP

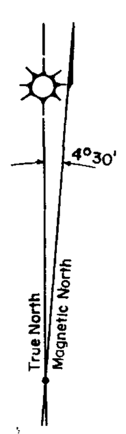
FOLIATION

SHEAR ZONE

TECTONIC BRECCIA

LOCATION DIAGRAM





INDEX TO ADJOINING SHEETS

AYERS ROCK	KULGERA	FINKE
WOODROFFE	ALBERGA	ABMINGA
LINDSAY	EVERARD	WINTINNA

APPROX. PROFILE SCALE

2000 1000 0 GAMMAS

EXPLANATORY NOTES

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

THE SOUTH COMPONENT OF THE REGIONAL GRADIENT IN TOTAL MAGNETIC INTENSITY HAS BEEN REMOVED FROM EACH PROFILE BY ROTATION ABOUT THE POINT WHERE THE PROFILE INTERSECTS THE NORTHERN SURVEY BOUNDARY. THIS COMPONENT AMOUNTS TO 9.0 GAMMAS PER MILE.

GEOLOGY AFTER GEOLOGICAL SURVEY OF SOUTH AUSTRALIA DEPARTMENT OF MINES, ADELAIDE

TOPOGRAPHICAL LEGEND

ROAD OR TRACK

RIVER OR CREEK

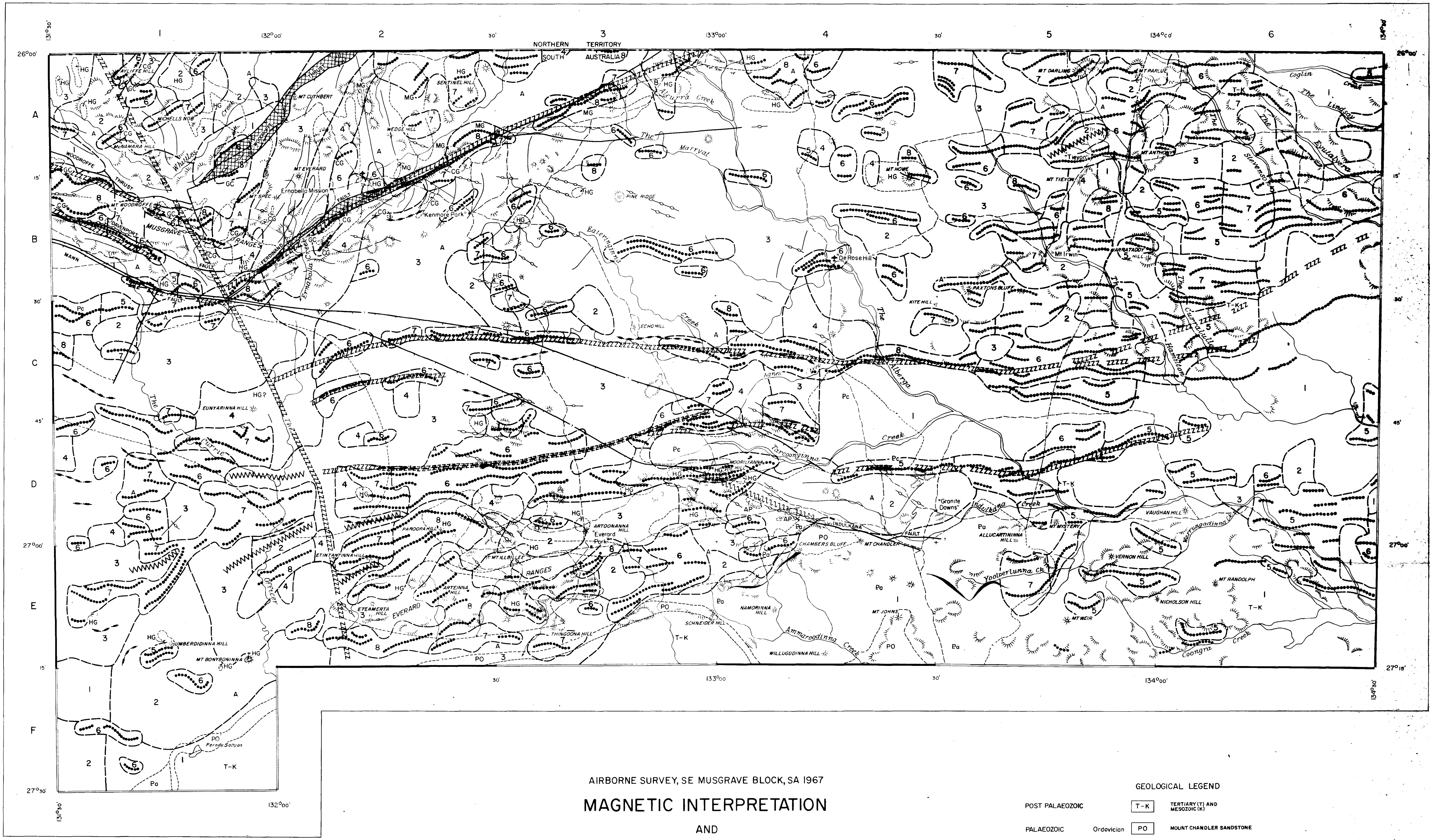
HOMESTEAD

HILL FEATURE

AERODROME

TO ACCOMPANY RECORD No. 1968/51

G53/B1-45



AIRBORNE SURVEY, SE MUSGRAVE BLOCK, SA 1967

MAGNETIC INTERPRETATION

AND

GEOLOGY

MILES 10 0 10 20 30 40 MILES

KILOMETRES 0 0 10 20 30 40 50 60 KILOMETRES

GEOLOGICAL LEGEND

POST PALAEOZOIC		T-K	TERTIARY (T) AND MESOZOIC (K)
PALAEOZOIC	Ordovician	PO	MOUNT CHANDLER SANDSTONE
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GEOLOGICAL BOUNDARY

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FOLIATION

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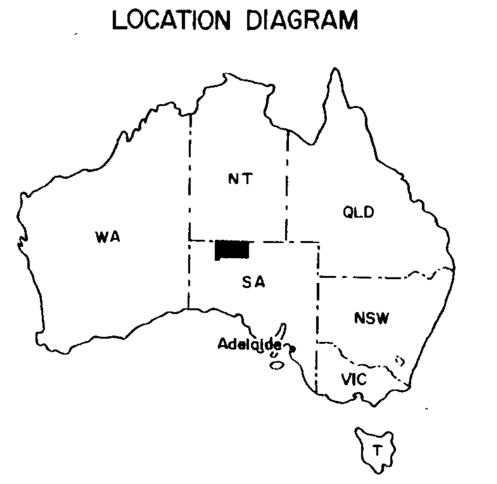
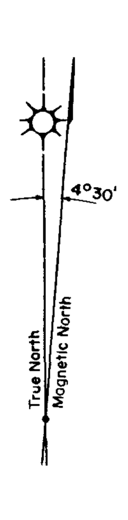
TECTONIC BRECCIA

LOCATION DIAGRAM





INDEX TO ADJOINING SHEETS

AYERS ROCK	KULGERA	FINKE
WOODROFFE	ALBERGA	ABMINGA
LINDSAY	EVERARD	WINTINNA

GEOPHYSICAL LEGEND

- MAGNETIC TREND POSITIVE
- MAGNETIC TREND NEGATIVE
- 2 MAGNETIC ZONE
- WWWW FOLD AXIS
- ZZZZZZZ INTERPRETED FAULT

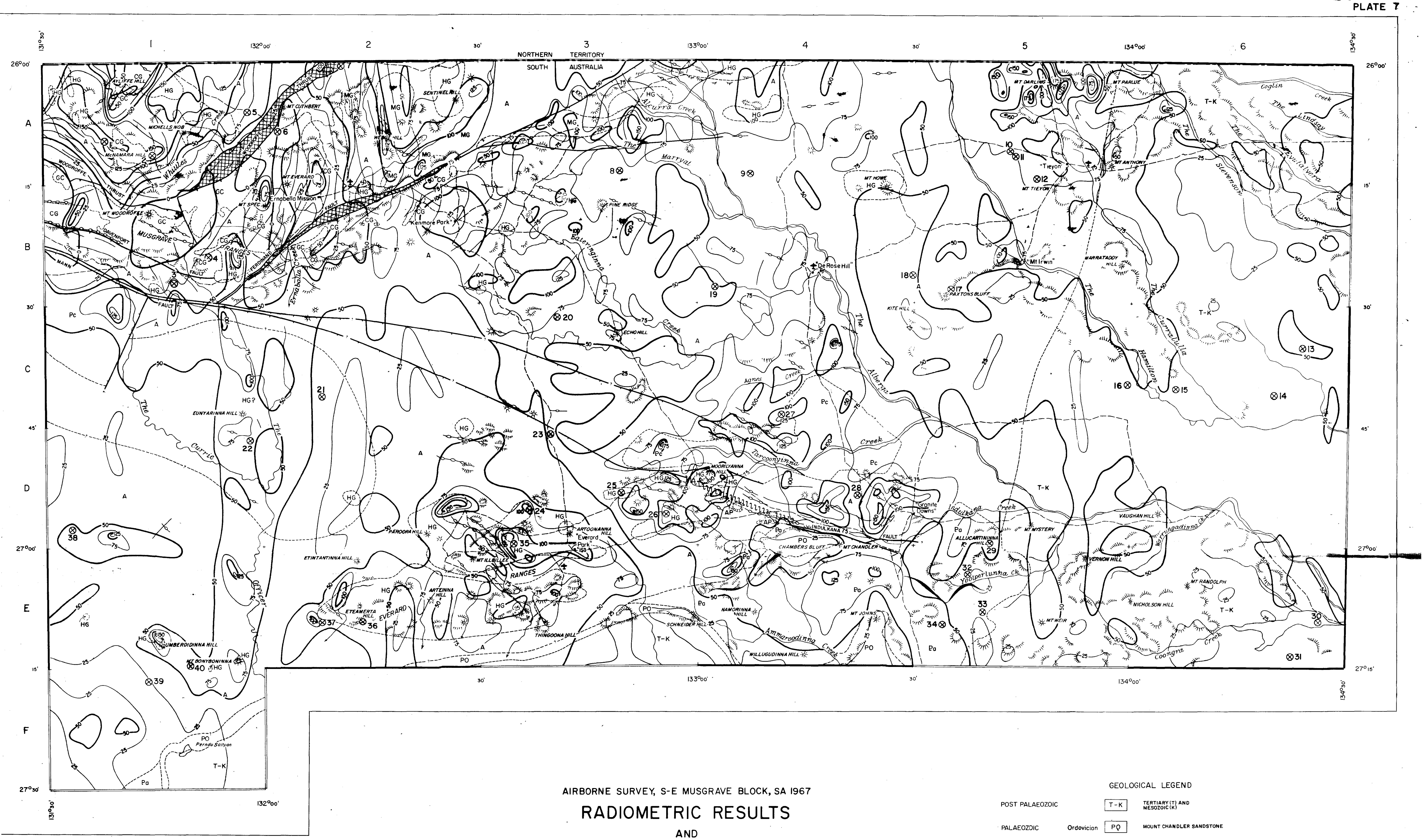
TOPOGRAPHICAL LEGEND

- ROAD OR TRACK
- RIVER OR CREEK
- HOMESTEAD
- HILL FEATURE
- AERODROME

GEOLOGY AFTER GEOLOGICAL SURVEY OF SOUTH AUSTRALIA
DEPARTMENT OF MINES, ADELAIDE

TO ACCOMPANY RECORD No. 1968/51

G53/BI-47



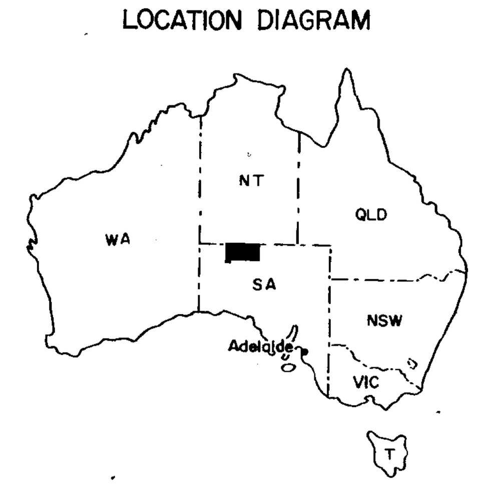
(BASED ON G53/BO-10)
(BASED ON G53/BI-42)

AIRBORNE SURVEY, S-E MUSGRAVE BLOCK, SA 1967

RADIOMETRIC RESULTS AND GEOLOGY

MILES 10 0 10 20 30 40 MILES
KILOMETRES 0 0 10 20 30 40 50 60 KILOMETRES

LOCATION DIAGRAM



True North
Magnetic North
4°30'

INDEX TO ADJOINING SHEETS

AYERS ROCK	KULGERA	FINKE
WOODROFFE	ALBERGA	ABMINGA
LINDSAY	EVERARD	WINTINNA

GEOPHYSICAL LEGEND

25, 0 — RADIOMETRIC CONTOURS, COUNTS PER SECOND

⊗10 — RADIOMETRIC ANOMALY RESTRICTED SOURCE (ANOMALIES ARE NUMBERED FOR REFERENCE ONLY)

TOPOGRAPHICAL LEGEND

- ROAD OR TRACK
- RIVER OR CREEK
- HOMESTEAD
- HILL FEATURE
- AERODROME

GEOLOGICAL LEGEND

POST PALAEOZOIC		T-K	TERTIARY (T) AND MESOZOIC (K)
PALAEOZOIC	Ordovician	PO	MOUNT CHANDLER SANDSTONE
PROTEROZOIC	Adelaidean	Pa	MAINLY SLATES, SHALES AND TILLITES BASALT AND/OR IRON FORMATION
	Carpentarian	Pc	LEVENGER ARKOSE AND MOORILYANNA CONGLOMERATE
OLDER PRECAMBRIAN	Crystalline Basement Rocks of Musgrave Block	A	UNDIFFERENTIATED CRYSTALLINE BASEMENT ROCKS
			DOLERITE DYKES
		GC	BASIC AND ULTRABASIC INTRUSIVES OF GILES COMPLEX
		MG	MICROADAMELLITE AND MICROGRANITE
		HG	BIOTITE ADAMELLITE AND HORNBLENDE ADAMELLITE
		CG	HYPERSTHENE ADAMELLITE
		AP	APLITE OF INDULKANA SHEAR ZONE
		HG?	UNDIFFERENTIATED GRANITE ROCKS

- GEOLOGICAL BOUNDARY
- FAULT
- FAULT, STRIKE AND DIRECTION OF DIP
- THRUST OR MAJOR SHEAR ZONE, STRIKE AND DIRECTION OF DIP
- FOLIATION
- SHEAR ZONE
- TECTONIC BRECCIA

GEOLOGY AFTER GEOLOGICAL SURVEY OF SOUTH AUSTRALIA
DEPARTMENT OF MINES, ADELAIDE

TO ACCOMPANY RECORD No. 1968/51

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