REPORT 187

Amadeus Basin Airborne, Magnetic and Radiometric Survey, Northern Territory, 1969

by

G. A. YOUNG and E. P. SHELLEY

DEPARTMENT OF NATIONAL RESOURCES

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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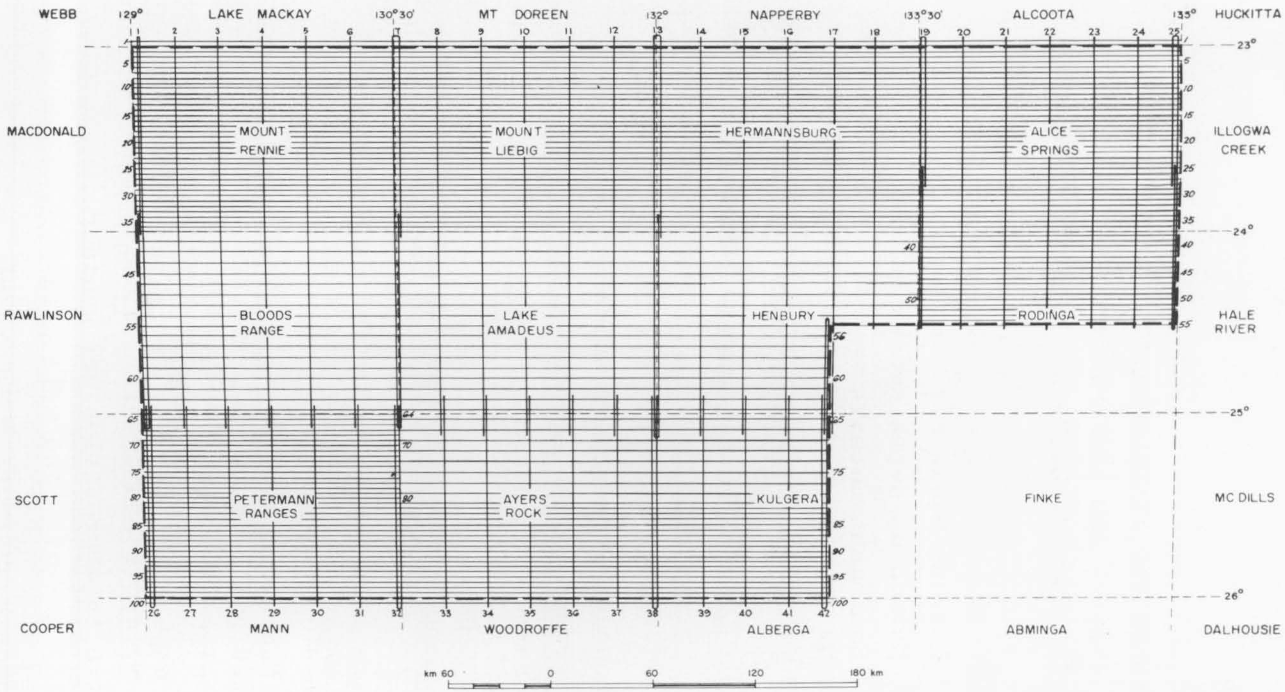

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Fig. 1. Flight-line and tie line system

SUMMARY

An airborne magnetic and radiometric survey of the greater part of the Amadeus Basin in the Northern Territory was flown in 1965.

The general structure of the basin interpreted from the magnetic results agrees well with gravity data. The magnetic basement attains a maximum depth of 38 000 ft (11 500 m) below sea level in the Amadeus Gravity Depression in the MOUNT LIEBIG 1:250 000 Sheet area.* Numerous basement high and low features resolved from the magnetic data have their gravity counterparts. In addition, seismic data agree well with basement form determined in the Gosses Bluff and Ooraminna localities.

The magnetic data reveal that the strong Bouguer anomaly gradients north and southwest of the basin are produced by changes in basement rock type. In areas of basement outcrop, magnetic anomaly trends are in general ill defined. The more clearly resolved trends north of the basin are oriented east-west. A similar trend is apparent within the basin near its northern margin. Elsewhere within the basin anomaly trends are oriented northeast or northwest.

Numerous small magnetic anomalies in the southwest Amadeus Basin suggest that volcanic activity was widespread during the Proterozoic era.

A contour presentation of the radiometric data reveals a correlation between radioactive 'highs' and sediments of the Larapinta and Pertaoorrta Groups. Well logs show that both shale and phosphorite produce gamma radiation; that associated with the shale appears to be the more significant. A radioactive 'high' associated with the Johnny Creek Anticline suggests that this is the most promising area for further search for phosphate deposits.

* In this Report, 1:250 000 Sheet areas are in capital letters to distinguish them from ordinary place names.

INTRODUCTION

An airborne magnetic and radiometric survey was flown over the greater part of the Amadeus Basin and the surrounding Precambrian basement during the period May to November 1965. The area surveyed is enclosed by latitudes 23° to 26°S and longitudes 129° to 135°E and includes the MOUNT RENNIE, BLOODS RANGE, PETERMANN RANGES, MOUNT LIEBIG, LAKE AMADEUS, AYERS ROCK, HERMANNSBURG, and ALICE SPRINGS 1:250 000 Sheet areas and parts of the HENBURY, KULGERA, and RODINGA 1:250 000 Sheet areas shown in Figure 1.

The survey was designed primarily to provide the magnetic data needed to determine the basement structure within the sedimentary basin in order to aid oil exploration and geological mapping. The radiometric data were required to test the suitability of the airborne radiometric method in the exploration for phosphate deposits in the Ordovician sediments. The association of uranium with sedimentary rocks, including phosphates, has previously been summarized by Bell (1955).

Survey operations were carried out by the BMR aircraft VH-MIN equipped with a fluxgate magnetometer, two scintillographs, and associated navigation instrumentation. Details of the equipment are given in Appendix C. The survey flight pattern incorporated east-west lines spaced at 2-mile or 4-mile (3.2 or 6.4 km) intervals and north-south tie-lines spaced at 15-mile (24 km) intervals as shown in Figure 1. Survey altitude was nominally 800 ft (240 m) above ground level and navigation was by reference to aerial photographs. A few traverses were flown at an altitude of 11 000 ft (3350 m) above sea level to obtain additional magnetic data.

During the period 1956 to 1964 field parties from the Geological Branch of the Bureau of Mineral Resources (BMR) were engaged in a program of geological mapping of the map areas listed above and coloured geological maps at a scale of 1:250 000 have been published. Before this, photo-interpretation maps of selected areas were prepared for BMR by the Institut Francais du Petrole (Scanvic, 1961). Geological maps of the survey area at smaller scales have been compiled by Quinlan (1962), Barrie (1964), and Forman (1964).

The main features of the Amadeus Basin are the thick pile of sedimentary rocks which extend in age from Proterozoic to Middle Palaeozoic and range in thickness to over 30 000 ft (9000 m), and the development within the sediments of great anticlinal structures that parallel the Basin edges and extend over great distances.

The favourable assessment of the economic petroleum prospects of the Amadeus region by Magellan Petroleum (NT) Pty Ltd led Exoil N.L. to enter into an exploration partnership in 1962. The first well drilled by Exoil N.L. southeast of Alice Springs (Ooraminna No 1) encountered combustible hydrocarbon gas in the Upper Proterozoic Areyonga Formation. Subsequent wells established the presence of free oil and substantial petroliferous gas flows in the Lower Palaeozoic sediments.

Phosphorite deposits were first noted in the Amadeus Basin in 1961 (Wells et al., 1965). They occur as thin phosphate-rich beds in the Ordovician Larapinta Group. All four formations of the Larapinta Group are phosphatic but except in the Stairway Sandstone the phosphate content is very low. During 1963, drill tests were made in the Stairway Sandstone to determine the thickness, distribution, and grade of the phosphorite beds. The most significant indication of phosphate was obtained in DDH/AP4 (Pl. 8) which was located near a gravity 'high' on the Angas Downs Gravity Ridge (Pl. 6). Barrie (1964) considered that as phosphate may be controlled by topographic highs on the sea-floor and as the Angas Downs Gravity Ridge was probably a reflection of a topographic ridge on the Ordovician sea-floor, there may be a correlation between phosphate distribution and gravity ridges.

Gravity coverage of the entire survey area has been made by BMR helicopter-borne surveys. The eastern part of the Amadeus Basin was included in a survey in 1961 (Langron, 1962) and the western part in a 1962 survey (Lonsdale & Flavelle, 1963). The Bouguer anomaly map produced for the area (Pl. 6) reveals extensive structural information concerning the geology of the basin and the underlying Precambrian basement. This information is correlated with the magnetic data later in this Report.

Magnetic surveys previously flown in or adjacent to the present survey area included two reconnaissance traverses flown from Alice Springs to the Tomkinson Ranges and to Giles by BMR (Goodeve, 1961). A series of four traverses were flown in BLOODS RANGE and MOUNT RENNIE by Aero Service Ltd for Roset Pty Ltd in 1963. In the same year Aero Service Ltd flew a more detailed survey for Exoil (NSW) Pty Ltd, covering FINKE and parts of RODINGA, HENBURY, KULGERA, and AYERS ROCK. During July 1965, Adastra Hunting Geophysics Pty Ltd flew an aeromagnetic survey of Davenport Hills for Reef Exploration Pty Ltd. This survey was within MOUNT RENNIE and BLOODS RANGE, duplicating to some extent the aeromagnetic coverage of this region. Flight-line orientation was northwest and the survey altitude 3000 ft (900 m) above sea level. The interpretation of these surveys is discussed later.

BMR has made three seismic surveys (Pl. 6) for oil exploration within the Amadeus Basin (Turpie & Moss, 1963; Moss, 1964 and 1966). Results from the first survey showed that the Palm Valley anticlinal structure exists at depth and includes at least 18 000 ft (5500 m) of sediments. In the locality three miles (5 km) east of Hermannsburg Mission, good reflections were obtained from depths in excess of 26 000 ft (8000 m) (Turpie & Moss, 1963).

The second seismic survey revealed that the Missionary Plain Syncline contained 26 000 ft (8000 m) of sediments at Gardiner Range Fault and 33 000 ft (1000 m) at a locality 25 miles (40 km) farther north. Gosses Bluff was shown to be a sedimentary feature and not an expression of basement relief. The nature of the Archaean/sediment contact was not resolved owing to poor reflections (Moss, 1964).

The seismic traverse from Alice Springs to Deep Well across the Ooraminna Anticline in 1962 indicated that the sediments are about 20 000 ft (6000 m) thick to the north and south of the anticline and thin to about 16 000 ft (5000 m) over the anticline (Moss, 1966).

Seismic and gravity surveys were made by Geophysical Associates International for Magellan Petroleum (NT) Pty Ltd (Magellan, 1966) in the Mount Rennie/Ooraminna areas and by Namco International Inc. for Exoil (NSW) Pty Ltd (Exoil, 1966) in KULGERA. The results are discussed later in this Report.

GEOLOGY

The Amadeus Basin is an intracratonic depression in which sedimentary rocks ranging in age from Proterozoic to Upper Palaeozoic have been deposited. About 33 000 ft (10 000 m) of sedimentary rocks are preserved.

The older Precambrian basement comprises the Arunta Complex along the northern margin of the basin, and the Musgrave-Mann complex and Olia Gneiss in the south. The Arunta Complex of igneous and metamorphic rocks was deformed during the Arunta Orogeny, before deposition of the sedimentary rocks of the Amadeus Basin. In the southwest, younger Precambrian basement sediments and volcanic rocks lie

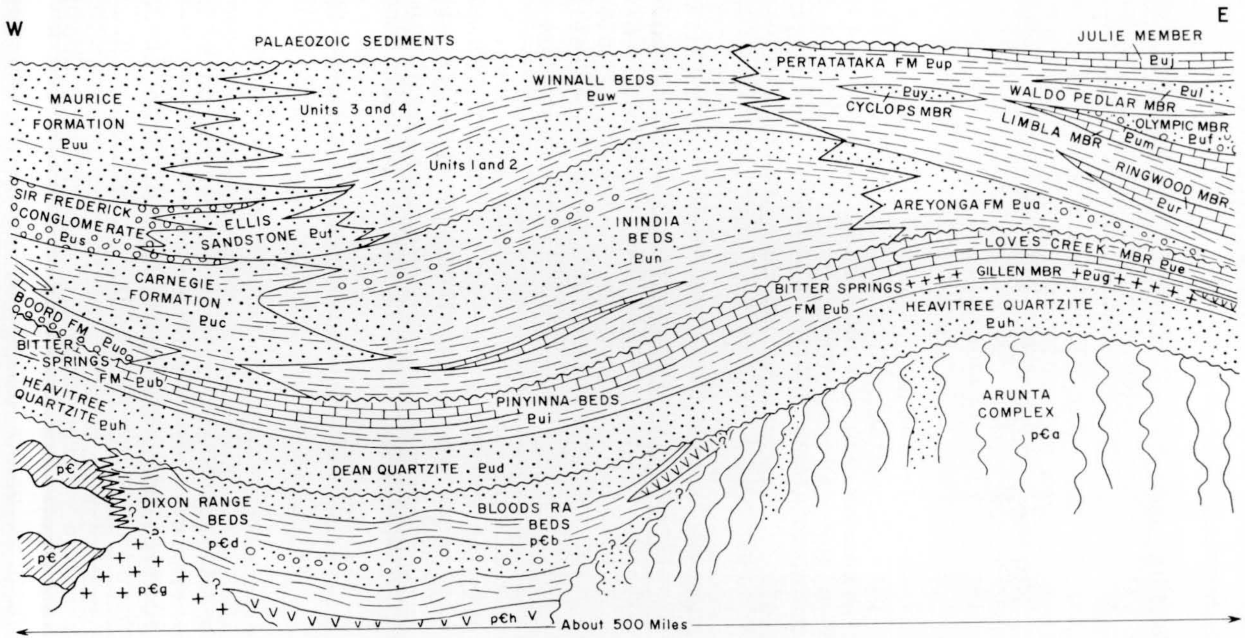


Fig. 2. Relations of Proterozoic units

between the older Precambrian rocks and the oldest sediments in the basin. The relations of the Proterozoic units are given in Figure 2.

The stratigraphy of the Amadeus Basin is given in Figure 3. The reader should refer to Wells et al. (1970) for a full account of the geology of the Amadeus Basin.

The two most important occurrences of hydrocarbons in the basin are wet gas accumulations in the Mereenie and Palm Valley Anticlines; in both, production comes chiefly from the upper part of the Cambro-Ordovician Pacoota Sandstone. Small amounts of oil have been obtained from the Mereenie Anticline, but the permeability in the reservoir rocks is insufficient to give significant oil production. The Ordovician and Cambrian sediments offer the best prospects for petroleum accumulation, and the Missionary Plain Syncline in the northern part of the basin is thought to be the most prospective area. Several large structures, with closure in Ordovician and Cambrian rocks, have been mapped under the Devono-Carboniferous cover rocks.

Pelletal phosphorites occur in the Areyonga Formation, Tempe Formation, Pacoota Sandstone, Horn Valley Siltstone, Stairway Sandstone, and Stokes Siltstone. Schmerber & Ozimic (1966) report phosphate intervals in the Bitter Springs and Pertatataka Formations. In the Stairway Sandstone the phosphatic bands are up to 8 inches (20 cm) thick and contain up to 22 percent P_2O_5.

Phosphatic sediments can carry appreciable quantities of uranium, which is thought to enter the phosphate minerals in isomorphous substitution for calcium (Bell, 1955). Accordingly an airborne scintillometer was operated to determine the value of such a tool in the search for phosphate in the Amadeus Basin.

MAGNETIC RESULTS AND INTERPRETATION

The magnetic profiles were reduced from the original charts to a scale of 1:250 000 for composite presentation with current editions of the BMR 1:250 000 Geological Maps (Young & Shelley, 1966). To simplify data presentation in this Report, a selection of magnetic profiles has been displayed at a scale of 1:1 000 000 as shown in plates 1 and 2. In addition, a composite presentation of magnetic contours is shown in Plate 3 based on a series of maps published by BMR (1969a to i, 1971a, 1971b).

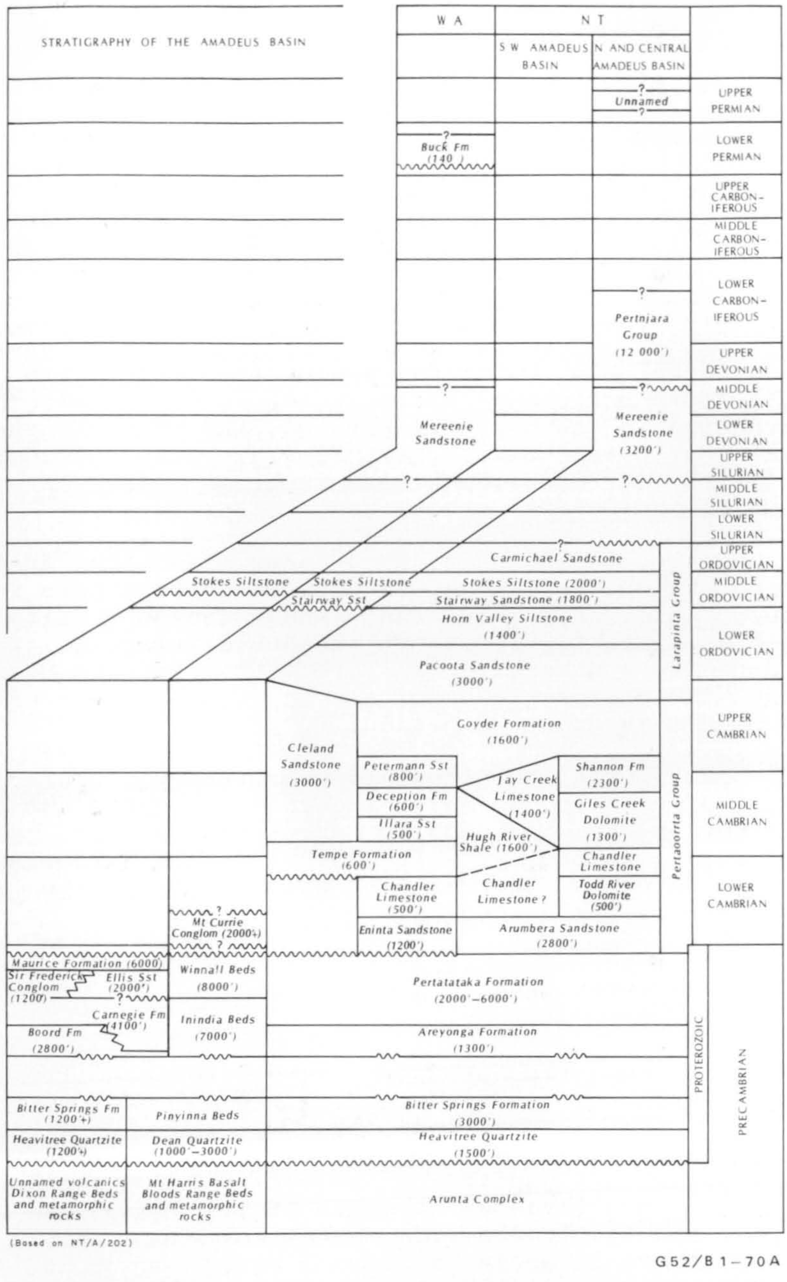


Fig. 3. Stratigraphy of the Amadeus Basin

Plate 4 shows total magnetic intensity profiles at a scale of 1:1 000 000 recorded on flights made at 11 000 ft (3350 m) above sea level. Comparison with the magnetic data in Plate 1 shows that the profiles in Plate 4 provide greater resolution of some of the major deep-seated magnetic sources, thereby improving the reliability of their interpretation.

The interpretation of magnetic data in Plate 5 is quantitative within the sedimentary basin, but only qualitative in areas of basement outcrop to the north and south. The magnetic basement surface is indicated within the sedimentary basin by 'depth to magnetic basement' contours at intervals of 2000 ft (600 m). The probable error of the depth estimates controlling these contours is about 10 percent.

In both the northern and southern areas of basement outcrop, zones have been defined with reference to the prominent magnetic characteristics listed below.

Northern basement

Zone	Magnetic character
A	Magnetic anomalies mainly less than 50 gammas
B	Magnetic anomalies of random shape mainly in the range 50-250 gammas or of east-west elongation in the range of 50-500 gammas
C	Magnetic anomalies of complex shape mainly in the range 250-1000 gammas

Southern basement

Zone	Magnetic character
A	Magnetic anomalies mainly less than 50 gammas
B	Magnetic anomalies mainly in the range 50-250 gammas
C	Magnetic anomalies mainly in the range 250-1000 gammas

In general, basement rocks are thought to have an increasing basic content progressing from zone A to zone C. Therefore it is to be expected that the zones and their boundaries will show correlation with geological and other geophysical features.

The geological significance of the zones is discussed later in dealing with magnetic and radiometric interpretation.

Northern basement outcrop

The aeromagnetic data shown in Plates 2 and 3 reveal an abrupt change in magnetic character near the centres of MOUNT RENNIE, MOUNT LIEBIG, HERMANNSBURG, and ALICE SPRINGS. This indicates abutment of the sedimentary rocks of the Amadeus Basin against the metamorphic-igneous rocks of the Arunta Complex. In general, the magnetically inferred boundary between these two units agrees closely with that geologically mapped.

The magnetic data displayed in profile and contour forms in Plates 2 and 3 reveal three distinct sets of linear anomalies approximately oriented 040°, 090°, and 140°. Anomalies with trend 090° are the most clearly resolved, their shape and extent being suggestive of dyke-type sources associated with faulting. These anomalies are most common in MOUNT RENNIE. The cross-cutting anomalies oriented 040° and 140° appear to increase in number eastwards from MOUNT RENNIE to HERMANNSBURG, thereby progressively increasing the complexity of the aeromagnetic contour pattern. In the easternmost Sheet area, ALICE SPRINGS, anomaly complexity is such that few anomaly trends can be resolved. An overall assessment of the aeromagnetic contours indicates that magnetic strike is preferentially oriented 090° which parallels surface geological trends.

The east-west trend is further reflected by the boundary between zones B and C (Pl. 5). This coincides approximately with the line of the maximum gravity gradient to the north of the Amadeus Basin (Pl. 6). The increase in magnetic disturbance north of this boundary is interpreted as evidence for an increase in the basic nature of the basement rocks. This change in rock type would be compatible with the form of the Bouguer anomaly as an increase in the basic nature of rocks is generally associated with an increase in their density.

In HERMANNSBURG and ALICE SPRINGS, zones of type A appear to correlate with the Ormiston and Arltunga Nappe Complexes (Pl. 5). This magnetic character is interpreted as evidence of the presence of acidic basement rocks in these localities, which would support the hypothesis of Forman et al. (1967) that less dense basement rocks form the cores of the nappes.

The A-type zone in west MOUNT LIEBIG (Pl. 5) correlates with a major granite outcrop. The westerly continuation of the geological unit into MOUNT RENNIE in an unchanged form as indicated on the Amadeus Basin (West) geological map (Wells et al., 1970) is not supported by the magnetic data. An acceptable interpretation of the magnetic data would involve a major granitic body traversed by a series of narrow basic rock units, possibly dykes, which strike east-west.

In northeast MOUNT RENNIE a major magnetic anomaly trending 070° coincides with a major gravity 'high' and is interpreted as evidence for the presence of a basic or ultrabasic igneous body.

Intense magnetic disturbance is confined to ALICE SPRINGS, where anomaly amplitudes commonly exceed 2000 gammas. Iron and copper mineralization is known near some of the anomalies (I. Youles, pers. comm.). An anomaly at latitude 23°03'S, longitude 133°46'E was indicated by a detailed aeromagnetic survey used in the search for copper orebodies (Tipper, 1969); the source of the anomaly corresponds to an outcrop of quartz-garnet-magnetite rock.

Southern basement outcrop

The contact between the sedimentary rocks of the Amadeus Basin and the basement rocks is shown by the aeromagnetic data in Plates 2 and 3 to pass through south BLOODS RANGE, west and south AYERS ROCK, and south KULGERA. The southern boundary of the basin is not so well defined by the magnetic data as the northern boundary owing to the presence of minor magnetic anomalies within the basin. Throughout AYERS ROCK there are magnetic anomalies caused by sources near to surface level. Those anomalies which occur within the area of sedimentation suggest the presence of dyke swarms or volcanic rocks.

Correlation between the magnetically inferred southern boundary of the Amadeus Basin and that mapped geologically is possible only in BLOODS RANGE, where there is good agreement. Elsewhere the inferred boundary is invariably to the north of basement exposures.

Inspection of the magnetic profiles in Plates 1 and 2 and the magnetic contours in Plate 3 indicates that there are three sets of magnetic lineations oriented approximately 040°, 090°, and 140°. These are similar to those in the northern basement area. There are also several magnetic lineations striking approximately 000° in east PETERMANN RANGES.

The trends oriented 140° in KULGERA, AYERS ROCK, and northeast PETERMANN RANGES, and the trends oriented 090° in southwest BLOODS RANGE reflect the regional geological strike and are parallel to the edges of the basin. The 000° trends in PETERMANN RANGES and the 040° trends in AYERS ROCK parallel air-photo trend-lines which obviously reflect local structure. The 090° trends in southwest PETERMANN RANGES occur in an area of rocks of the Musgrave-Mann complex. These trends can be correlated with air-photo trends and faults.

In the southern basement outcrop area the zone boundaries show a predominant trend of 110°, which is similar to some gravity trends. The zones show good correlation with Bouguer gravity features and fair to good correlation with geology (Pls 5 & 6). The northern shelf of the Mount Davies Gravity High (Lonsdale & Flavelle, 1963) is clearly associated with a C-type zone which can be correlated with rocks of the Musgrave-Mann complex and Olia Gneiss. The Woodroffe Thrust which marks the northern extent of the Musgrave-Mann complex is not defined by the magnetic data in this area. Some anomalies, however, were recorded over the Woodroffe Thrust in the WOODROFFE area to the south (Shelley & Downie, 1971). In south KULGERA the C-type zone boundary is interpreted as representing the northern extent of the Musgrave-Mann complex.

The Katamala Gravity Embayment to the northeast corresponds to a C-type zone. The suggestion by Lonsdale & Flavelle (1963) that this feature results from low-density Lower Proterozoic or Archaean rocks which include numerous granitic intrusions is supported by the magnetic data; however, the presence of shallow magnetic sources would not support the alternative interpretation of a narrow trough of Proterozoic sediments 2000 to 4000+ ft (600 to 1200+ m) thick.

The A-type zone in northeast PETERMANN RANGES broadly corresponds to a region of Lower Palaeozoic sedimentation. It is deduced that the magnetic disturbance characteristic of basement type B has been suppressed by burial of Lower Proterozoic rocks beneath minor Lower

Palaeozoic sedimentation. Magnetic profiles in Plates 2 and 4 illustrate the effect of increased 'depth of burial' on the magnetic character of basement type B in PETERMANN RANGES.

Little correlation is apparent between the Ayers Rock Gravity Depression and the magnetic character of the basement rocks that crop out to the south. The distribution of zones in southwest AYERS ROCK would give limited support for the presence of intermediate-type basement rocks immediately north of latitude 25°55'S and more basic denser rocks to the south. On the northwest flank of the gravity depression, the C-type zone trending 290° has an associated Bouguer anomaly 'ridge' of approximately 10 milligals relief. Within AYERS ROCK the magnetic basement at the boundary of the basin appears to be downfaulted to the north by about 10 000 ft (3000 m). The magnetic data could, however, support an easterly continuation of the Petermann Ranges Nappe structure as shown in the diagrammatic section in Plate 5. The boundary of the basin cuts across the gravity depression and either structural interpretation appears to contradict the gravity data.

The C-type zone in BLOODS RANGE includes the 090°-trending magnetic lineations previously mentioned. This zone can be correlated with thick sequences of the Mount Harris Basalt and the Bloods Range Beds in the Petermann Ranges Nappe. These rocks may also be the cause of the Bloods Range Gravity High.

The B-type zone in north PETERMANN RANGES broadly corresponds to the Pottoyu Granite Complex and Olia Gneiss. The B-type zone in southwest AYERS ROCK can be correlated with granite, Proterozoic sediments, and Olia Gneiss.

Amadeus Basin

The aeromagnetic data in Plates 1, 2, and 3 reveal major basement susceptibility contrasts within the basin. Many of these are oriented approximately 040° and 140°, directions similar to those evident for anomalies in areas of basement outcrop. Analysis of selected anomalies indicates that the susceptibility contrasts have values in the range 0.5 - 5.0 x 10^{-3} c.g.s. units. This range of susceptibility contrasts and their alignment indicate that the magnetic basement underlying the basin represents plutonic bodies within or at the surface of the Arunta Complex.

The general form of the magnetic basement surface as shown in Plate 5 bears a high degree of similarity to that indicated by gravity data. The correspondence between the magnetic and gravity data is very high in terms of both major and minor features of basement relief. However, some disparity exists in the structure at the sediment/basement boundary as determined by the two methods.

Regional magnetic profiles obtained from the tie-lines (Pl. 3) commonly show a low susceptibility contrast at the northern margin of the basin. A much larger susceptibility contrast is associated with the contact between zones B and C in the outcropping basement to the north, as shown in Plate 5. It is apparent that a much greater northerly increase in the magnetic mineral content and, therefore, rock density is present at the contact between zones B and C than at the boundary of the basin. This would explain the apparent disagreement between the magnetic and gravity data.

It is not possible at present to determine fully the nature of the northern sediment/basement contact. The magnetic anomalies shown at the basin boundary on ties 8, 9, 18, 20, and 21 are interpreted as being caused by near-vertical 'dyke-like' sources. These may be readily produced along faulted contacts or very steep unconformities between the sediments and the basement.

Within the area of basement outcrop in BLOODS RANGE and AYERS ROCK south of the basin boundary, the magnetic data show some evidence for the presence of an upper and lower magnetic basement. The latter is probably Archaean and underlies the exposed or near-surface rocks which are of Proterozoic or older age. The magnetic basement contours shown in Plate 5 in areas of basement outcrop refer to the lower magnetic horizon.

The axis defined by the deepest parts of the magnetic basement lies in the southern parts of MOUNT RENNIE, MOUNT LIEBIG, HERMANNSBURG, and ALICE SPRINGS. This is collinear with the axis of thickest sedimentary sections as indicated by gravity data. The deepest parts of the basin are shown by the 36 000-ft (11 000 m) and 34 000-ft (10 500 m) contours in the east and west, respectively, of MOUNT LIEBIG. These depths agree approximately with the quoted estimate of maximum thickness of sedimentary rocks (BMR, 1962). Within the areal extent of the deepest basin deep (L3), three distinct magnetic anomalies are seen to have some correlation with Bouguer gravity lows. This correlation of magnetic and gravity response is interpreted as evidence for the magnetic anomalies arising from crystalline basement sources in contrast to a thickening of sediments accounting for the gravity anomalies.

Basement depth contours in Plate 5 illustrate the presence of a number of high and low features and associated basement gradients. These are briefly described in the following paragraphs. Section thicknesses have been obtained by assuming an average surface level of 1000 ft (300 m) above mean sea level.

L1. This is a basement depression along the axis of the Amadeus Basin. The magnetic data indicate that the maximum possible sedimentary thickness contained in this structure is 29 000 ft (8800 m). However, as this interpretation is controlled by only a few isolated depth estimates, the reliability of the figure is not high. This depression in the magnetic basement corresponds to an extension of the comparatively thick sediments of the Amadeus Basin (Lonsdale & Flavelle, 1963).

The interpretation of aeromagnetic data obtained by Adastra Hunting Geophysics Pty Ltd in this area indicated a maximum depth to magnetic basement of 20 000 ft (6000 m) below sea level (Reef, 1965). It is most unlikely that their interpretation is any more reliable than that contained in this Report, as in both cases similar interpretation problems were encountered. The rapid southerly rise of magnetic basement in BLOODS RANGE shown by Adastra Hunting Geophysics Pty Ltd is most probably caused by the recognition of only one magnetic horizon, whereas the current interpretation indicates two.

L2 and L3. These are the most prominent magnetic basement depressions resolved from the magnetic data and indicate the axis of the deepest part of the Amadeus Basin. These depressions coincide with the regions of maximum sedimentary thickness indicated by the Amadeus Gravity Depression. The maximum possible sedimentary thicknesses determined in these two depressions are 35 000 and 37 000 ft (10 500 and 11 000 m), respectively.

It is possible that the crystalline basement is shallower than the magnetic basement in the region of L2 as the granite basement that crops out to the north shows little associated magnetic disturbance. Such an interpretation would assume that the acidic rocks of the Arunta Complex are intruded at depth by a basic plutonic body.

Near Gosses Bluff two deep-seated magnetic anomalies mutually interfere. Reliable depth estimates which control the eastern form of L3 are obtained on the outer flanks of these anomalies and are in the range 31 000 to 39 000 ft (9500 and 12 000 m) below sea level. The shallower depth estimates which range from 20 000 to 32 000 ft

(6000 to 10 000 m) below sea level occur in the area of maximum anomaly interference and are therefore considered unreliable.

L4. This is a magnetic basement depression south of Alice Springs, containing a maximum possible sedimentary thickness of 23 000 ft (7000 m). Gravity data confirm the presence of a basement depression and, in addition, a seismic traverse made by BMR across the Ooraminna Anticline (Moss, 1966) closely supports the structures inferred from the magnetic data as shown in Plate 5.

A line through L1, H1, L2, L3, and L4 intersects seven major magnetic highs evident in Plate 3. This line parallels both the northern basin boundary and magnetic lineations referred to in the discussion of the northern basement. It is therefore suggested that the sources of all these anomalies are genetically related.

L5. This magnetic basement depression is elongated in a northwesterly direction and attains a maximum depth of 34 000 ft (10 000 m) below sea level. Gravity data do not support the presence of this basement feature and, in view of the few depth estimates controlling the inferred structure, the interpretation is unreliable.

L6. A southerly extension of the basement depression L3 gives rise to a subsidiary basement depression L6 which is associated with a gravity 'low'. The gravity data show little evidence for elongation of this basement feature although the magnetic data indicate that L6 has a northwesterly trend similar to L5,

L7. A possible basement fault G5 in southeast HENBURY is interpreted as a giving rise to the basement depression L7, in which the maximum possible sedimentary thickness is 23 000 ft (7000 m). Gravity data support the southeast elongation of the depression and the presence of a median basement ridge.

L8. This basement depression in central RODINGA corresponds to the western end of the East Rodinga Gravity Low. The extension of this feature to the east is only marginally apparent by the slight embayment of the 6000 ft (1800 m) magnetic basement contour. Lonsdale & Flavelle (1963) correlated the gravity 'low' with a small basin of Palaeozoic sediments. The magnetic data indicate that crystalline basement underlying this structure is within 10 000 ft (3000 m) of sea level.

L9. A basement 'low' with a relief of about 6000 ft (1800 m) is superimposed on a northerly-dipping basement surface. Deep-seated magnetic anomalies were unresolvable over the central and western parts of this basement feature, thereby limiting depth control mainly to the north and east flanks. No corresponding feature is indicated by the gravity data.

H1. This uplift in the magnetic basement surface forms a south-trending ridge of about 6000 ft (1800 m) relief that protrudes into the Amadeus Gravity Depression in MOUNT RENNIE. The magnetic basement contours north and south of G1 indicate that H1 was originally continuous to the north, but was probably affected later by major faulting. Gravity data show limited evidence for the presence of this basement ridge. However, the resolution is poor.

H2, H6, and H7. These three 'highs' form a major ridge in the magnetic basement extending from east LAKE AMADEUS to central southern MOUNT LIEBIG. The major basement 'high', H7, has a relief of about 10 000 ft (3000 m) with respect to the general basement level. Feature H6 is a small associated 'high' west-northwest of H7, and H2 form a broad ridge which extends northwards into the Amadeus Gravity Depression, separating the two major magnetic basement depressions L2 and L3. All these magnetic basement features have high gravity correlation as shown by Plates 5 and 6.

The apparent lineaments produced by the magnetic basement contours between L5 and H6 and H7 between L6 and H6 and H7 are interpreted as evidence for possible major basement faulting. An ellipsoidal magnetic anomaly, long axis oriented 140°, centred at 25°00'S and 132°00'E, which offsets a magnetic low oriented 040°, supports the interpretation of a lineament between L5 and H6 and H7. The trend of these lineaments is northwest, which is intermediate between the trends of surface structural fold axes and faulting.

H3. The magnetic basement depression associated with the eastern end of the Amadeus Gravity Depression is subdivided by a west-trending ridge, H3, of about 2000 ft (600 m) relief. The Bouguer anomaly contours show some correlation with this basement ridge, but a more significant gravity 'high' of 15 mGal to the west has no reflection in the relief of the magnetic basement.

H4 and H5. In northeast BLOODS RANGE and northwest LAKE AMADEUS, two narrow ridges (H4 and H5) in the magnetic basement protrude into the Amadeus Gravity Depression in a northeast direction and have reliefs of about 4000 ft and 2000 ft (1200 and 600 m), respectively. A ridge in the magnetic contours coincides with the more pronounced feature H4, but no similar feature is associated with H5. The trends of the Bouguer anomaly contours show little agreement with the more pronounced basement ridge H4, but moderate agreement with H5.

H8. This is a minor 'high' of only 2000 ft (600 m) relief near the northern boundary of HENBURY. It is elongated in an east-west direction and lies on the south-eastern slope of the major low feature L3. It can be correlated with a minor gravity ridge in the Bouguer anomaly contours, although some offset between the magnetic and gravity data is apparent. The resolution of the magnetic basement feature H8 is not high owing to the limited number of depth estimates available.

H9. This forms a prominent 'high' in the magnetic basement near central HENBURY and has an associated west-trending ridge. The relief of H9 is about 6000 ft (1800 m). A well defined magnetic high is associated with this basement feature, but there is little agreement apparent between the magnetic and gravity data.

H10. This feature forms a significant 'high' in the magnetic basement of about 4000 ft (1200 m) relief and 6000 ft (1800 m) depth relative to sea level. The northerly strike of this feature is clearly reflected by the magnetic contours. The Bouguer anomaly contours west of the East Rodinga Gravity Low show good correlation with the magnetic basement surface at and about H10.

H11. This magnetic basement feature constitutes a ridge of 2000 to 4000 ft (600 to 1200 m) relief trending northwest from KULGERA towards LAKE AMADEUS. It shows some correlation with the Bouguer anomaly contours about the eastern end of the Angas Downs Gravity Ridge. It is concluded that the gravity feature attributed to shallow Lower Proterozoic rocks is also controlled by upwarping of the Archaean basement.

The depth estimate of 16 400 ft (5000 m) obtained from the anomaly at latitude $25^{\circ}00'$S, longitude $132^{\circ}00'$E is considered to be reliable as it has been confirmed by a high-altitude magnetic traverse (Pl. 4). Earlier interpretation by Aero Service Ltd (Exoil, 1963) of this anomaly in northwest KULGERA yielded a basement depth of 11 300 ft (3400 m) below sea level, which would now appear incorrect.

H12. This minor basement 'high' correlates with a protrusion of the Angas Downs Gravity Ridge. Previous work by Aero Service Ltd indicated a more pronounced 'high' of 5000 ft (1500 m) relief located at a depth of 4000 ft (1200 m) below sea level.

G1. A discontinuity in the magnetic basement contours in southwest MOUNT RENNIE produced the trend G1. This trend is interpreted as the result of a fault which strikes east-northeast for about 75 miles (120 km) and which has a throw of about 10 000 ft (3000 m). A geologically mapped fault zone occurs close to this inferred fault. No gravity feature can be correlated with this structure; however, Bouguer anomaly contours parallel the trend.

G2 and G3. These gradients of the magnetic basement surface occur in east ALICE SPRINGS and in east and north RODINGA. The basin appears to deepen westward initially and thence to the north. The correlation between the Bouguer contours and the magnetic basement depth contours is good and, in addition, the form of the structure associated with G3 is supported by seismic data (Moss, 1966) shown in Plate 6.

G4. This trend represents a strong gradient in southwest LAKE AMADEUS and is caused by the magnetic basement rising steeply towards the southwest. Although the gravity data show a general shallowing of the basin to the south, there is a notable difference between the trend of the Bouguer anomaly contours and those of the magnetic basement surface.

G5. This magnetic basement trend is interpreted as resulting from a steep northerly rise in the basement surface in southeast HENBURY. The gradient trend is to the northwest and is probably caused by a fault with a throw of about 4000 ft (1200 m). Such a fault is shown in a cross-section included in the HENBURY 1:250 000 Geological Sheet (Ranford et al., 1965). In addition, gravity data show general agreement with this fault and the associated depression to the southwest.

G6. The basement escarpment G6 is interpreted as an Archaean basement upwarp continuous with G4 and appears to delineate the southeast margin of the main area of sedimentation. The correlation of this feature with gravity data is not high. The Bouguer anomaly contours indicate a more gradual shallowing of the basin through LAKE AMADEUS, the magnetic basement 'low' L5 having a marked effect on G6.

G7. The easterly continuation of G7 into FINKE has been interpreted as evidence for a fault (Exoil, 1963). Current interpretation would support this deduction.

Correlation of magnetic and seismic data

The interpreted magnetic basement generally agrees well with basin structure determined by seismic surveys. Plate 6 and Figure 4 show the locations of seismic surveys in the area. The depths of the deepest reflectors are included in these illustrations.

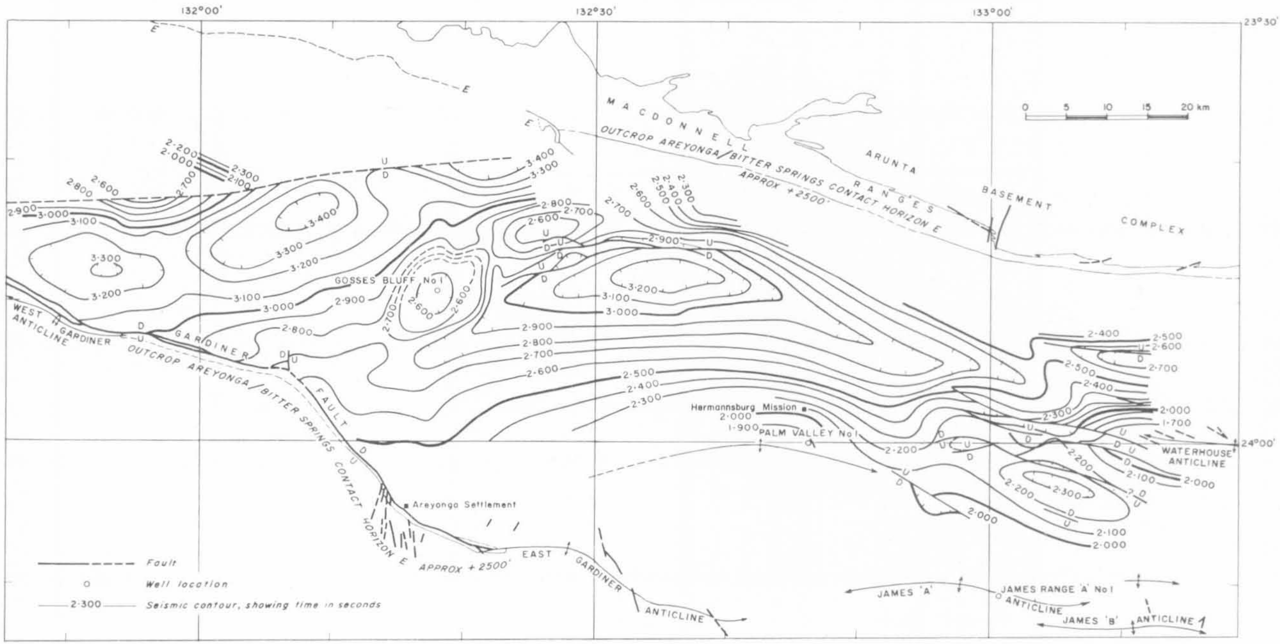
The seismic data obtained by BMR surveys show very good agreement with the general form of the magnetic basement about the eastern part of L3 (Pl. 5). The magnetic data do not reveal any minor basement uplift associated with Gosses Bluff, a result supporting recent interpretation of seismic data (Milton et al., 1972).

The seismic survey in the Missionary Plain locality (Magellan, 1966) indicated that locally the maximum thickness of sediments overlying the Bitter Springs Formation is about 28 000 ft (8500 m) immediately northwest of Gosses Bluff. This estimate is based on a two-way reflection time of 3.46 seconds and a mean sectional velocity of 16 000 ft/s (4900 m/s). The Bitter Springs Formation and the Heavitree Quartzite probably add 4000 ft (1200 m) to the sedimentary section, suggesting a maximum basement depth of about 32 000 ft (9800 m) below ground level, i,e. 31 000 ft (9500 m) below sea level, which agrees well with basement depth shown in Plate 5.

The subsequent survey in the Mount Rennie and Ooraminna localities (Magellan, 1966) indicated an easterly basement shallowing towards Ooraminna No. 1. The two-way reflection time contours of 2.90 seconds and 2.70 seconds at longitudes 132°50' and 133°45'E, immediately south of the MacDonnell Ranges (Fig. 4), indicate basement depths of about 25 000 ft and 23 000 ft (7500 and 7000 m), respectively. These estimates are based on the same parameters as used in the Gosses Bluff locality and agree closely with values of 24 000 ft and 22 000 ft (7300 and 6700 m) shown by the basement contours in Plate 5.

The depth and form of the contours of 'Horizon E' shown in Figure 4 agree well with the magnetic basement contours shown in Plate 5. The rate of shallowing of Horizon E to the south is in places considerably greater than that of the magnetic basement. Such a configuration of basement and sedimentary horizons suggests a thickening of the Bitter Springs section across the axis of the Palm Valley and Waterhouse Range Anticlines.

In general the resolution of structural features shown by Horizon E is much greater than that interpreted from the magnetic data of the underlying basement. Regional



G52/B1-71A

Fig. 4. Missionary Plain seismic survey showing contours on deep reflectors

gravity contours in the Ooraminna locality (Magellan, 1966) closely approximate magnetic basement contour form. This suggests that most structural features shown by Horizon E are restricted to the sedimentary section and have little basement expression.

Two basement depths estimates of 14 000 ft and 15 000 ft (4300 and 4600 m) below sea level near G3 (Pl. 5) were given a low 'weighting' by the authors in their original interpretation of the magnetic data owing mainly to the control on L4. Subsequent seismic data revealed a structural high in Horizon E at this locality, Orange No. 1 (Fig. 4), with a two-way reflection of time of 1.43 seconds. This corresponds to a miminum basement depth of 14 000 ft (4300 m) below sea level, assuming no major increase in the thickness of the Bitter Springs Formation. A local basement uplift is thereby interpreted to underlie the Orange structure.

The structure in the area between Ooraminna No. 1, Alice No. 1, and Mount Ooraminna as indicated by seismic data (Moss, 1966) is confirmed by the magnetic interpretation.

Results from the seismic reflection survey in KULGERA (Exoil, 1966) do not agree closely with the aeromagnetic interpretation. Plate 6 shows the locations of seismic traverses 2 and 3 and depths to the deepest reflector, which is interpreted as being near the top of the Bitter Springs Formation. Both seismic traverses indicate a tectonically disturbed region. In general the east-west traverse shows that the depth to the deepest reflector does not exceed 8000 ft (2400 m) below sea level in comparison to the magnetic basement depth of 12 000 ft (3600 m). This minimum difference in depth of 4000 ft (1200 m) is approximately equal to the section thicknesses of the Bitter Springs Formation and the Heavitree Quartzite, or equivalents. It does not seem likely, therefore, that any major thickness of Lower Proterozoic rocks underlies the Upper Proterozoic sequence here. The rapid thickening of the sedimentary sequence west of longitude 132°15'E along seismic traverse 2 agrees with the magnetic interpretation (L9); however, the general southerly thickening at this longitude along seismic traverse 3 is not supported by the magnetic interpretation.

The differences between the irregular surface mapped as the lowest seismic horizon (Top Salt, Bitter Springs Formation) and the simple form of the underlying magnetic basement along seismic traverse 3 (Pls 5 and 6) suggest that wedges of salt from the Bitter Springs Formation form diapiric structures on the south side of reverse faults.

RADIOMETRIC RESULTS AND INTERPRETATION

Profiles showing changes in level of radiometric intensity have been reduced to a scale of 1:250 000 for all flight-lines, but are not presented in this Report.

Plate 7 shows the composite radiometric contours at a scale of 1:1 000 000, superimposed on the geological compilation produced by Wells et al., (1970). Systematic errors revealed by east-west elongation of the radiometric contours are flight-line dependent: they are produced by minor changes in equipment operation or variations in the mean terrain clearance between adjacent flight-lines. The contour pattern about latitude 25°S is markedly affected by these errors.

Basement outcrop in MOUNT RENNIE, MOUNT LIEBIG, HERMANNSBURG, and ALICE SPRINGS

The radiometric contours indicate that the regions of granite and gneissic granite outcrop in MOUNT RENNIE and MOUNT LIEBIG occur in a belt of high radioactivity which trends east-west across the two areas. The similarity of radiometric character in the two areas is in contrast to the magnetic results which showed a marked change of response over granitic basement rock types.

In general, high radioactivity is associated with exposures of Precambrian basement rocks throughout HERMANNSBURG and ALICE SPRINGS, the latter area being particularly anomalous.

Over much of the area of basement outcrop there is a well defined correlation between high radioactivity and moderate-to-low magnetic disturbance. The abrupt change in basement rock type determined from the magnetic data, which coincided approximately with the steep gravity gradient, is also shown by the radiometric contours. The zone of basic rocks interpreted from the magnetic data (C-type zone) in general has low radioactivity.

Basement outcrop in BLOODS RANGE, PETERMANN RANGE, AYERS ROCK, and KULGERA

Radioactive anomalies form two distinct belts through PETERMANN RANGES and AYERS ROCK, which coincide with mapped exposures of undifferentiated Precambrian rocks. These belts have northwest and west trends and may be correlated with the previously mentioned B-type and C-type zones, respectively.

The alluvial cover in the region of the C-type zone between the two belts in PETERMANN RANGES probably masks radioactivity from the underlying basement rocks. Even so, it is to be expected that rocks of C-type zone would be less radioactive than those of B-type zone as the former are thought to be more basic.

Well defined easterly trends in south BLOODS RANGE parallel magnetic features resolved in this area. Precambrian basement rocks are again the source of anomalous radioactivity.

Amadeus Basin

Numerous radioactive anomalies have been delineated within the area of sedimentation, particularly in LAKE AMADEUS and HENBURY. Plate 7 shows that a high proportion of these anomalies are associated with exposures of the Larapinta and Pertaoorrta Groups in the Watson Range, Ochre Hill, Johnny Creek, Mereenie, Gardiner Range, and James Range Anticlines. Two other anomalies in northeast AYERS ROCKS and north-central KULGERA also coincide with small exposures of these rocks.

Composite well logs obtained from Alice No. 1 (Exoil N.L., 1964), East Mereenie No. 1 (Exoil N.L., 1965) and Palm Valley No. 1 (Magellan, 1965) show that considerable gamma radiation is associated with shales of the Pertnjara Group, Larapinta Group, and Pertaoorrta Group (Pl. 8). Sandstone and limstone beds have little radioactivity, the Mereenie Sandstone in particular showing little response on the gamma-ray logs.

The gamma-ray log (Pl. 8) for diamond-drill hole AP4 (Pl. 7) does not suggest that a large increase in gamma radiation is produced by phosphatic material included in the sediments of the Larapinta Group. The most outstanding radiometric 'high' which can be ascribed to phosphatic material occurs in the interval 251 to 265 ft. This correlates to an average P_2O_3 content of 3.3 percent over the range 248 to 259 ft (Barrie, 1964). It is important to note that Plate 7 does not show a radiometric 'high' near AP4 although sediments of the Larapinta Group crop out nearby.

The radioactive 'highs' apparent in the north of the Amadeus Basin (Pl. 7) are produced by the Brewer Conglomerate of the Pertnjara Group. This conglomerate contains a large proportion of igneous material (Wells et al., 1970) which accounts for the high radioactivity.

In general, few exposures of the phosphate-bearing Larapinta Group appear to be abnormally radioactive when compared to radioactivity exhibited by shales of the Pertaoorrta Group. The anomaly associated with the Johnny Creek Anticline is the most significant detected within the sediments of the Amadeus Basin, although the contribution of radioactivity from phosphate minerals is locally unknown.

CONCLUSIONS AND RECOMMENDATIONS

The moderate-to-high degree of correlation of the form of the magnetic basement with the Bouguer anomaly contours suggests that in most of the survey area the magnetic and crystalline basements are identical. The general absence of direct correlation of individual magnetic anomalies with Bouguer anomalies supports this conclusion as it appears that the Bouguer anomalies primarily depend upon the density contrast between the sediments and the crystalline basement, whereas magnetic anomalies are produced by intrabasement susceptibility contrasts. The density contrasts associated with the crystalline basement do not generally appear to be significant.

The magnetic basement underlying the Amadeus Basin has been interpreted as being of Arunta age, primarily on the assessment of anomaly amplitude and orientation. Some doubt exists as to the validity of this assumption owing to two unusual basement characteristics encountered. The first is the major difference in the dominant magnetic trend orientation within the basin as compared to the surrounding basement outcrop. It is possible that the more common northeast and northwest trends found within the basin result from susceptibility contrasts between ancient crystalline rocks, whereas the more common easterly trends in areas of basement outcrop reflect tectonic activity associated with basin development.

From these two hypotheses it may be concluded that the northeast and northwest trends in the basin and the east-west trends over the northern basement result from the Arunta and Alice Springs Orogenies, respectively. The general absence of east-west trends within the basin suggests that either the Alice Springs Orogeny had little effect upon basement rocks, or the sources are of such limited extent or of such low magnetic susceptibility that they are not recorded at the observation level. An exception to this hypothesis is the line of anomalies which parallels the northern boundary of the basin.

The second unusual characteristic is the rapid change in basement depth near the basin boundary. This severely restricts the recognition of typical magnetic anomalies associated with basement rocks.

The isolated high-level magnetic traverses located over basement outcrop yield qualitative information regarding the 'burial' of magnetic basement rocks. In particular, Lower Proterozoic rocks appear to produce very little magnetic disturbance when observed from an altitude of 9000 ft (2750 m) above the source. Greater resolution of some magnetic sources in ?Archaean basement rocks is obtained from these traverses, a few critical depth determinations being confirmed.

Well defined easterly magnetic trends detected in BLOODS RANGE have been correlated with exposures of Mount Harris Basalt. It is probable that magnetic data could greatly assist geological mapping in this region with reference to local basement structure. If such information is required it will be necessary to make a more detailed magnetic survey to resolve clearly the form of these magnetic anomalies. Interpretation of such work would take the form of an assessment of the disposition of thin sheet-type sources.

The presence of numerous magnetic anomalies distributed throughout the southwestern part of the basin suggests that widespread volcanic activity accompanied sedimentation in this region. Many magnetic anomalies appear to have the elongation and form typically associated with dykes: however, some detailed aeromagnetic traversing about Lake Amadeus failed to confirm this impression.

In general there is fair to good agreement between the interpretation of aeromagnetic data made by Aero Service Ltd (Exoil, 1963), Adastra Hunting Geophysics Pty Ltd (Reef, 1965), and that included in this Report. Correlation is best in RODINGA and HENBURY. In KULGERA similar basement form is shown by the interpretations of Aero Service Ltd and BMR, although a systematic difference in depth to basement of 30 percent is apparent, the former interpretation being the shallower. A similar situation exists in BLOODS RANGE and MOUNT RENNIE, where the interpretation by Adastra Hunting Geophysics indicates the shallower magnetic basement.

Radiometric results prove that in certain areas considerable radioactivity is associated with rocks of the Larapinta and Pertaoorrta Groups. It is essential that phosphatic rock samples obtained from the Larapinta Group be assayed for radioactive mineral content before entering into any further radiometric work in this region. If favourable results are obtained from such assays it is recommended that a detailed low-level gamma-ray spectrometer survey be flown over the Johnny Creek Anticline to assist in the search for economic phosphate deposits. This would give much greater resolution of radioactive anomalies and allow targets to be selected for ground geophysical, geological, or geochemical surveys.

The radioactive anomalies constituting a belt coincident with the Pottoyu Hills in PETERMANN RANGES indicate granitic-type rocks. The decrease in radioactivity and increase in magnetic disturbance over basement rocks to the south is interpreted as evidence for the occurrence of more basic basement rock types. This conclusion agrees with gravity data. A similar correlation of radiometric, magnetic, and gravity data is apparent to the north of the basin, where it is inferred that basement rocks become more basic to the north.

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APPENDIX A.

AMADEUS BASIN WELL DATA (as at 31 December 1966).

Name	Location	Total Depth (ft)	Remarks
Ooraminna No. 1	24°00'00"S 134°09'50"E F53/14 ALICE SPRINGS	6107	Gas show in Areyonga Formation
Alice No. 1.	23°54'47"S 133°58'00"E F52/16 ALICE SPRINGS	7518	Oil bleeding in Jay Creek Limestone
Mereenie No. 1	23°59'08"S 131°30'10"E F52/16 MOUNT LIEBIG	3983	Gas flow 11 MCF/D from Pacoota Sandstone
East Mereenie No. 1	24°00'31"S 131°33'51"E G52/4 LAKE AMADEUS	4710	Open hole flow 60 MCF/D. Completed as gas producer from Pacoota Sandstone
East Mereenie No. 2	24°02'47"S 131°38'50"E G52/4 LAKE AMADEUS	5175	Completed as gas-condensate producer from Pacoota Sandstone
East Mereenie No. 3	24°00'45"S 131°33'10"E G52/4 LAKE AMADEUS	5215	1400 ft-oil recovered from Pacoota Formation - not commercial. Plugged and abandoned.

APPENDIX A. (cont.)

Name	Location	Total Depth (ft)	Remarks
West Mereenie No. 1	23°56'57"S 131°24'44"E F52/16 MOUNT LIEBIG	5504	Completed in Cambrian limestone and sandstone as a gas-condensate producer from Pacoota Sandstone
West Mereenie No. 2	23°58'49"S 131°32'22"E F52/16 MOUNT LIEBIG	4997	Completed in Pacoota Formation as a gas producer (10.6 MCF/D). At 1170 ft oil, and at 280 ft oil-cut mud in DST.
Mt Charlotte No. 1	24°53'41"S 133°59'11"E G53/2 RODINGA	6943	Abandoned in salt (?Bitter Springs Formation)
Palm Valley No. 1	24°00'00"S 132°46'20"E F53/13 HERMANNSBURG	6658	Completed in Pacoota Formation. Gas flow 14 MCF/D from Horn Valley Siltstone and Pacoota and Stairway Sandstones
Johnny Creek No.1	24°08'46"S 131°29'41"E G52/4 LAKE AMADEUS	877	Abandoned in Goyder Formation
East Johnny Creek No. 1	24°11'00"S 131°37'55"E G52/4 LAKE AMADEUS	6344	Plugged and abandoned in Bitter Springs Formation. No showings of oil or gas
Gosses Bluff No. 1	23°49'15"S 132°18'00"E F53/13 HERMANNSBURG	4534	Abandoned in Stairway Sandstone

APPENDIX A. (cont.)

Name	Location	Total Depth (ft)	Remarks
James Range 'A' No. 1	24°10'42"S 133°00'40"E G53/1 HENBURY	3000	Plugged and abandoned in Bitter Springs Formation
Highway Anticline No. 1	24°20'23"S 133°27'06"E G53/1 HENBURY	3770	Plugged and abandoned in Jay Creek Limestone. No showings of oil or gas
Erldunda No. 1	25°18'30"S 133°11'48"E G53/5 KULGERA	5463	Plugged and abandoned in Bitter Springs Formation
Ochre Hill No. 1	24°07'58"S 131°23'49"E G52/e LAKE AMADEUS	3761	Plugged and abandoned in Bitter Springs Formation. No showings of oil or gas
Orange No. 1	24°02'34"S 133°46'32"E G53/2 RODINGA	8886	Bottomed in Arumbera Formation. Gas show at 7510 ft.
Waterhouse No. 1	24°01'00"S 133°31'00"E G53/2 RODINGA	3081	Abandoned in Arumbera Formation.

APPENDIX B

METHOD OF DEPTH DETERMINATION

Depth determinations were made by combined application of the half-maximum-slope method (Peters, 1949) and the straight-slope method (Vacquier et al., 1951) using the original charts for computations. The mean determination obtained by the two methods was accepted as the depth to the magnetic source, providing the deviation of this mean from either determination did not exceed 15 percent.

The horizontal distance between points of half-maximum slope varies from 1.2 times the depth for a thin sheet to 2.0 times the depth for the edge of a semi-infinite block. In most cases a factor of 1.6 was used. This is applicable to a body whose width is equal to about twice its depth. The straight-slope method of interpretation involves the measurement of the horizontal extent of the steepest part of the anomaly curve. In order to use this parameter to obtain the depth to the magnetic source it is necessary to multiply the straight-slope length by a factor within the range 1.0 to 1.8. A factor of 1.5 was used for all determinations.

In general, comparisons between adjacent profiles and orthogonal profiles enable an adjustment to be made for depth determinations influenced by oblique intersections of magnetic contours with flight-lines. Depth estimates remain uncorrected if the anomaly cannot be traced across neighbouring profiles, or if the field is too disturbed for a pattern to be seen. As the correction is simply the multiplication by the sine of the angle of intersection, uncorrected depths, which are common in regions of shallow or extremely deep basement, are maximum estimates.

Systematic errors are introduced by the application of standard factors for depth determinations in areas where they are inappropriate. Anomaly interpretation by curve-fitting methods (Gay, 1963) produces more reliable depth estimates provided that the anomalies have simple forms. This method of depth determination was used wherever possible to establish control depths and also to provide anomaly analysis for local adjustment of half-slope factors.

The anomalies interpreted by this method are shown in Plate 9 and the various parameters of each are listed in Table 1. In some cases compound magnetic anomalies have been reduced to theoretical constituent anomalies before interpretation.

No well drilled in the Amadeus Basin has bottomed in basement rocks. Absolute control for calibration of depth estimates is therefore not available. Limited seismic information was used where possible to obtain partial calibration of minimum depths to basement.

TABLE 1

		Curve parameter (Gay, 1963)		Model parameter				
Anomaly	Line	θ	R	Depth (ft)	Width (ft)	Strike	Dip	Susceptibility (10^{-3} c.g.s.)
1	41	-360	2.5	34 000	85 000	150°	54° to 240°	1.7
2	41	-360	2.5	31 000	77 500	010°	76° to 100°	1.1
3	62	-270	2	29 900	59 800	030°	35° to 300°	1.6
4	Tie 17	-300	3	18 400	55 200	050°	86° to 320°	0.7
5	Tie 14	-300	1	27 700	27 700	075°	82° to 165°	1.9
6	56	-280	3	28 300	85 200	015°	30° to 285°	0.9
7	63	-270	2	27 900	55 800	030°	35° to 300°	1.6
8	Tie 15	-340	1	33 000	33 000	060°	56° to 150°	3.6
*9	55	-230	4	16 000	64 000	150°	0°	0.4
10	47	-360	3	18 200	54 600	170°	80° to 260°	0.6
11	39	-330	2	27 000	54 000	155°	86° to 245°	0.5
12	65	-350	2	18 400	36 800	170°	84° to 80°	1.2
13	Trav C	-350	1.5	25 600	38 400	170°	84° to 80°	1.0
14	58	-360	.7	31 600	22 100	0°	90°	5.0
15	Trav B	-360	.5	40 600	20 300	0°	90°	5.8
16	55	-370	3	4 800	14 400	0°	80° to 270°	0.6
17	55	-360	2.5	11 000	27 500	175°	86° to 265°	1.1

TABLE 1. (cont.)

Anomaly	Line	Θ	R	Depth (ft)	Width (ft)	Strike	Dip	Susceptibility (10^{-3} c.g.s.
18	55	-360	2.0	10 000	20 000	17°	70° to 107°	1.3
19	48	-360	0	10 100	THIN	0°	90°	3.2
20	48	-360	0	10 100	THIN	0°	90°	3.2
21	48	-370	2	10 800	21 600	175°	74° to 265°	0.5

The locations of the magnetic anomalies are shown in Plates 1, 2 and 4

Depths are calculated relative to aircraft height.

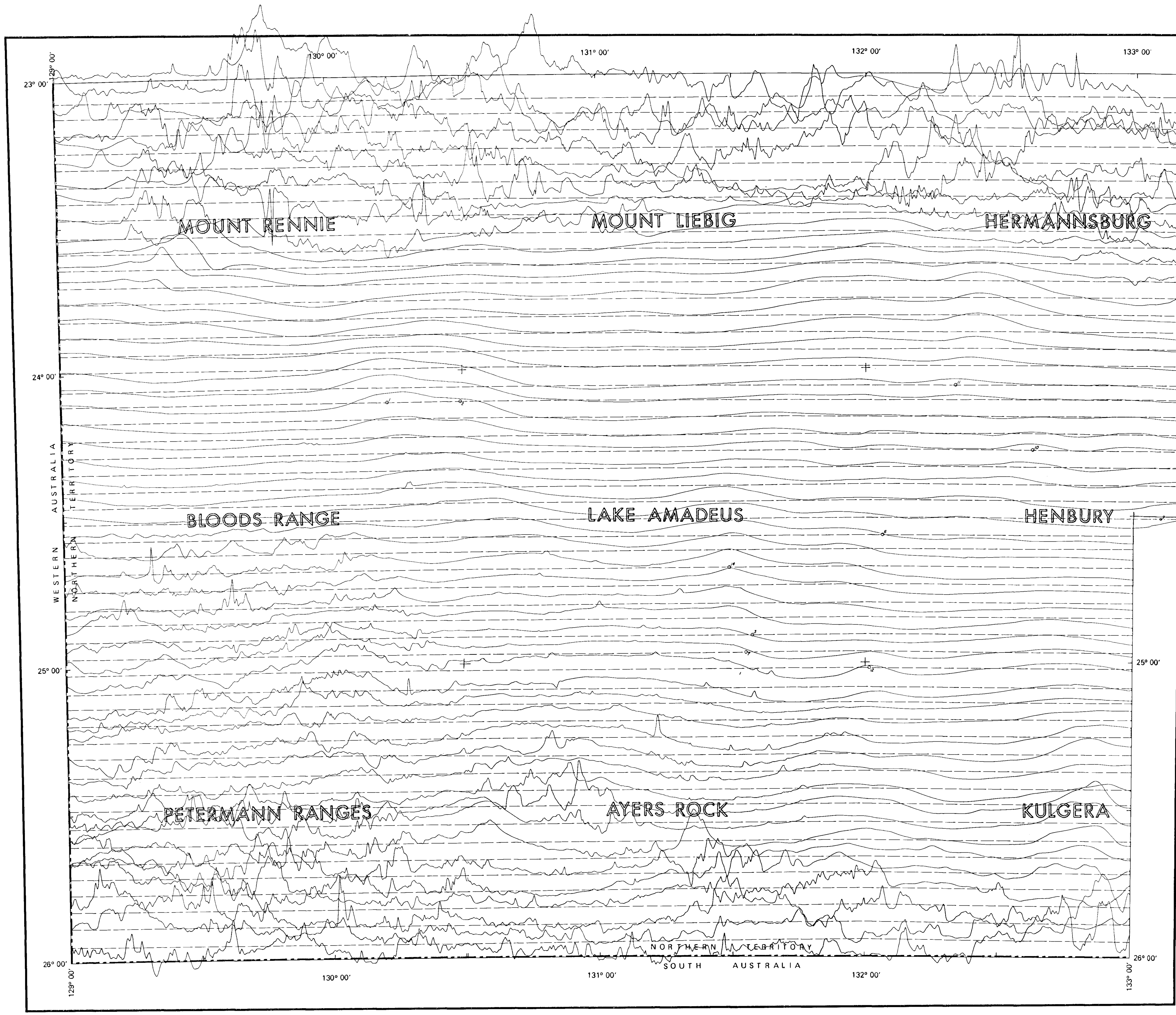
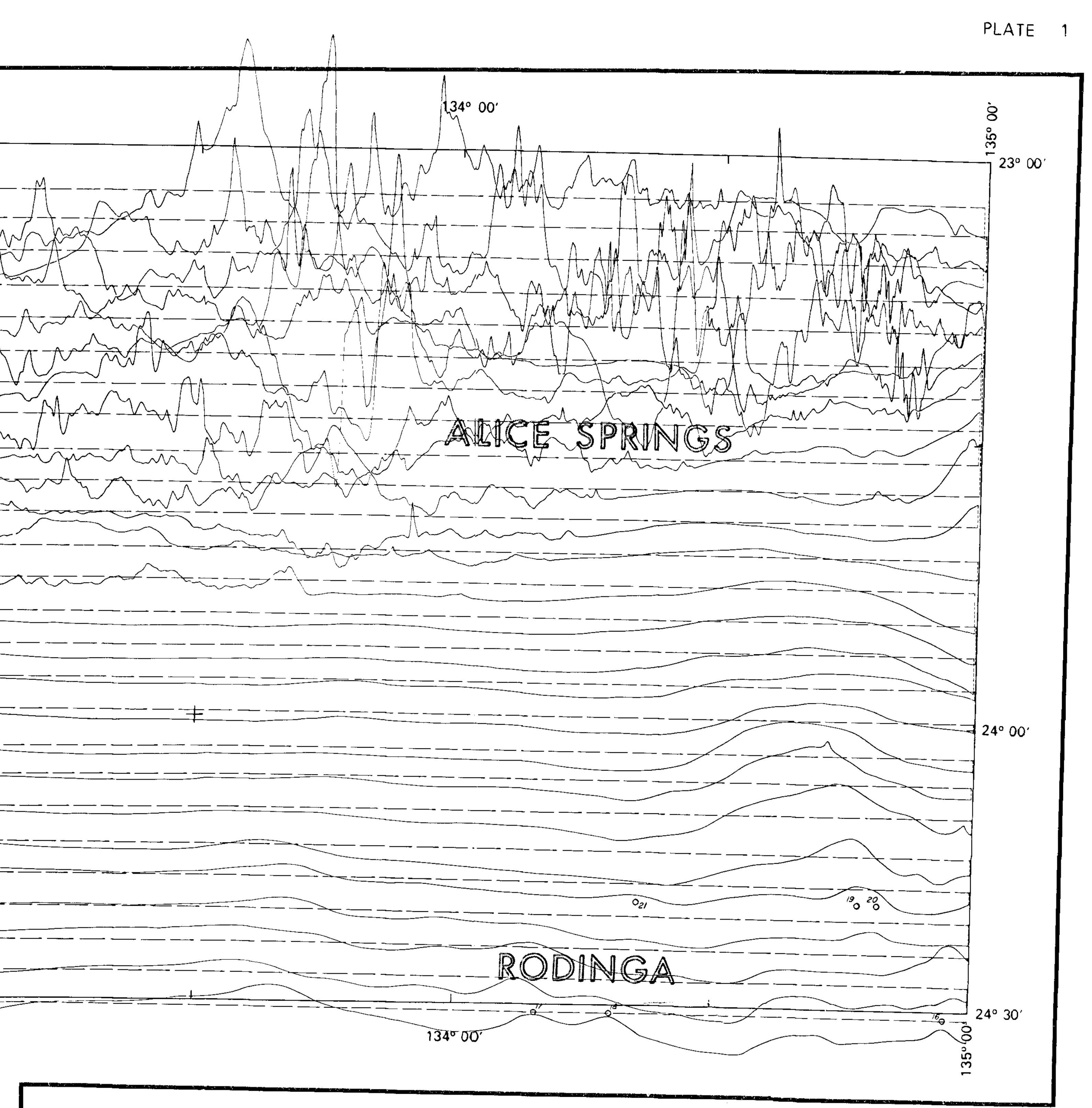
* Application of model curve is questionable because of the low dip-angle.

APPENDIX C

EQUIPMENT DETAILS

Magnetometers	:	MFS-5 saturable core fluxgate, tail-boom installation coupled to Speedomax and digital recorders. The Speedomax record sensitivity was set to 50 gammas/inch. MFD-3 saturable core fluxgate, ground installation for storm warning, coupled to Esterline-Angus recorder. The recorder sensitivity was set to 20 gammas/inch.
Scintillographs	:	Twin-crystal MEL scintillation detector heads inboard supplemented by single crystal detector head outboard (the latter suspended from a cable 200 ft below aircraft). Both scintillographs had time constants of 10 seconds and their outputs were coupled to DeVar recorder. The recorder sensitivity was set to 25 counts cm
Radio altimeter	:	STR30B, frequency-modulated type, output coupled to DeVar recorder
Air position indicator	:	Track recorded by DeVar recorder
Camera	:	BMR 35-mm strip

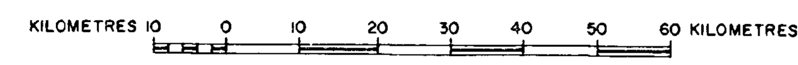
R76/1254 Cat.No.77 2424 5

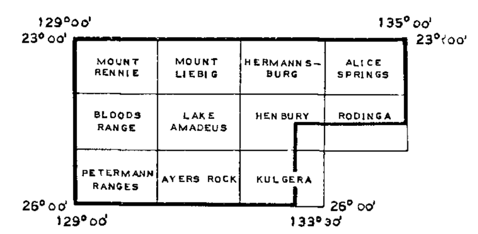
TOTAL MAGNETIC INTENSITY PROFILES

FLIGHT-LINES ORIENTED EAST-WEST

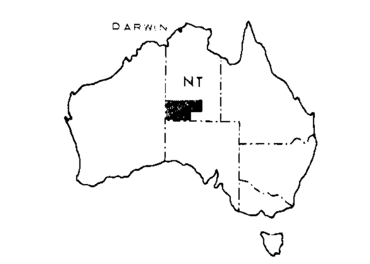
SCALE 1:1 000 000



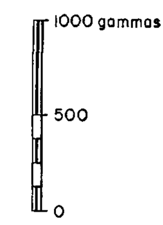
INDEX TO 1:250 000 MAP SERIES



LOCATION DIAGRAM



APPROX. PROFILE SCALE



EXPLANATORY NOTES

The survey was made with a DC 3 aircraft at an altitude of 800 feet above ground level along east-west oriented lines spaced two and four miles apart, and along north-south lines spaced fifteen miles apart.

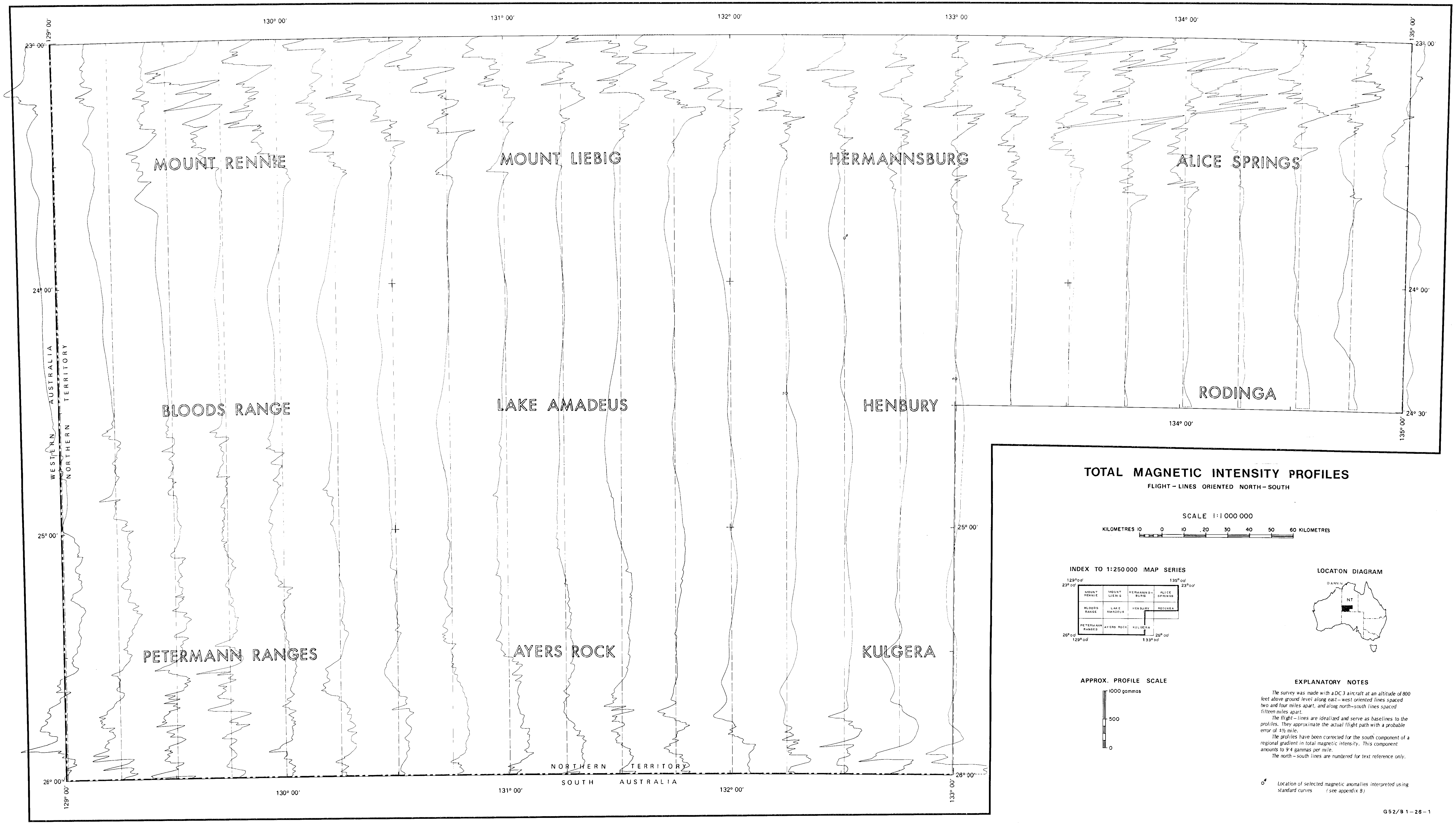
The flight-lines are idealized and serve as baselines to the profiles. They approximate the actual flight path with a probable error of ±½ mile.

The profiles have been corrected for the south component of a regional gradient in total magnetic intensity. This component amounts to 9·4 gammas per mile.

o[17] *Location of selected magnetic anomalies interpreted using standard curves (see appendix B)*

G52/B1-25-1

Based on A/80-72



TOTAL MAGNETIC INTENSITY PROFILES

FLIGHT – LINES ORIENTED NORTH – SOUTH

SCALE 1:1 000 000

KILOMETRES 10 0 10 20 30 40 50 60 KILOMETRES

EXPLANATORY NOTES

The survey was made with a DC 3 aircraft at an altitude of 800 feet above ground level along east – west oriented lines spaced two and four miles apart, and along north–south lines spaced fifteen miles apart.

The flight – lines are idealized and serve as baselines to the profiles. They approximate the actual flight path with a probable error of ±½ mile.

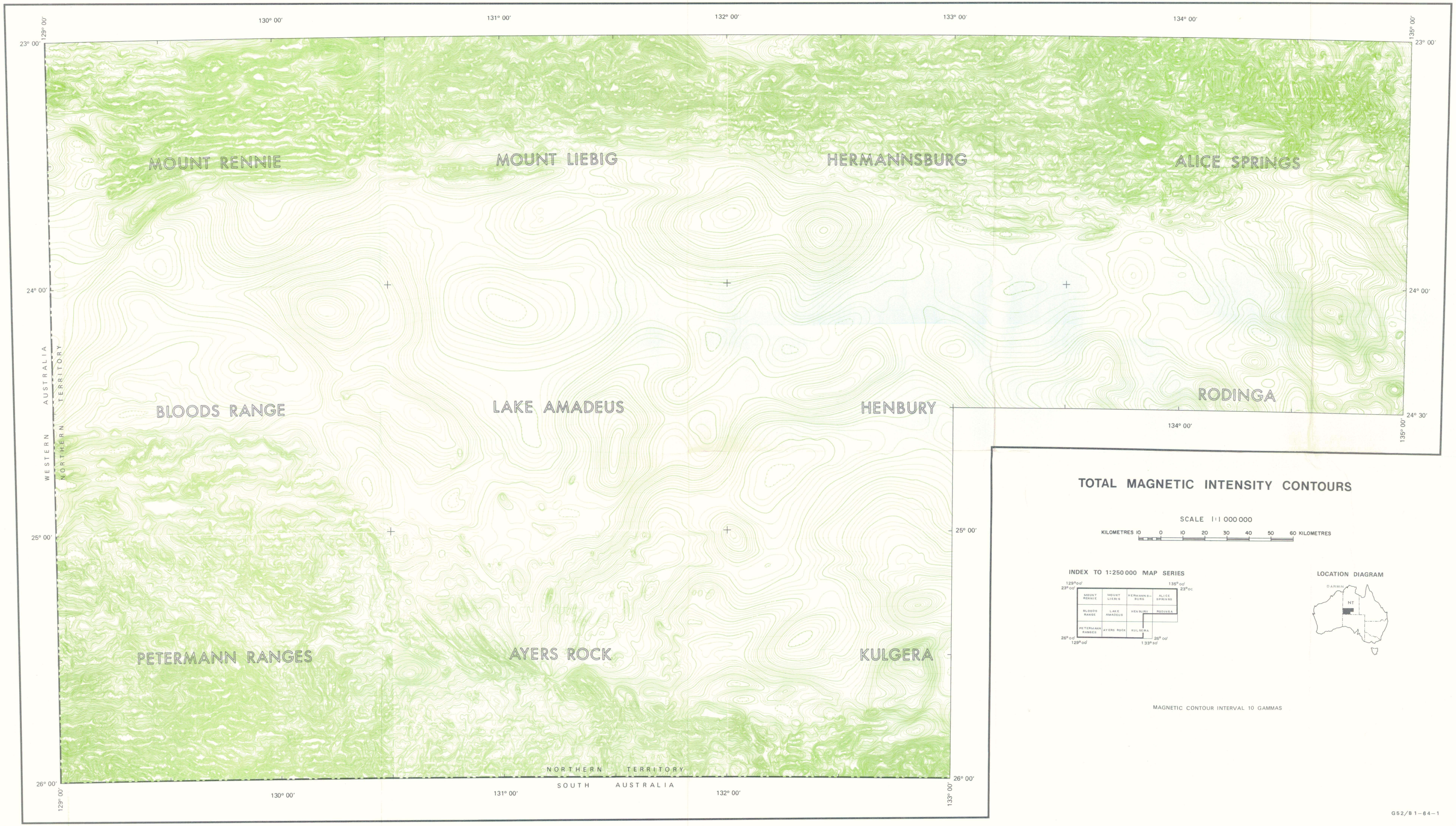
The profiles have been corrected for the south component of a regional gradient in total magnetic intensity. This component amounts to 9·4 gammas per mile.

The north – south lines are numbered for text reference only.

o[4] *Location of selected magnetic anomalies interpreted using standard curves (see appendix B)*

G52/B1–26–1

Based on A/80–72



TOTAL MAGNETIC INTENSITY CONTOURS

SCALE 1:1 000 000

KILOMETRES 10 0 10 20 30 40 50 60 KILOMETRES

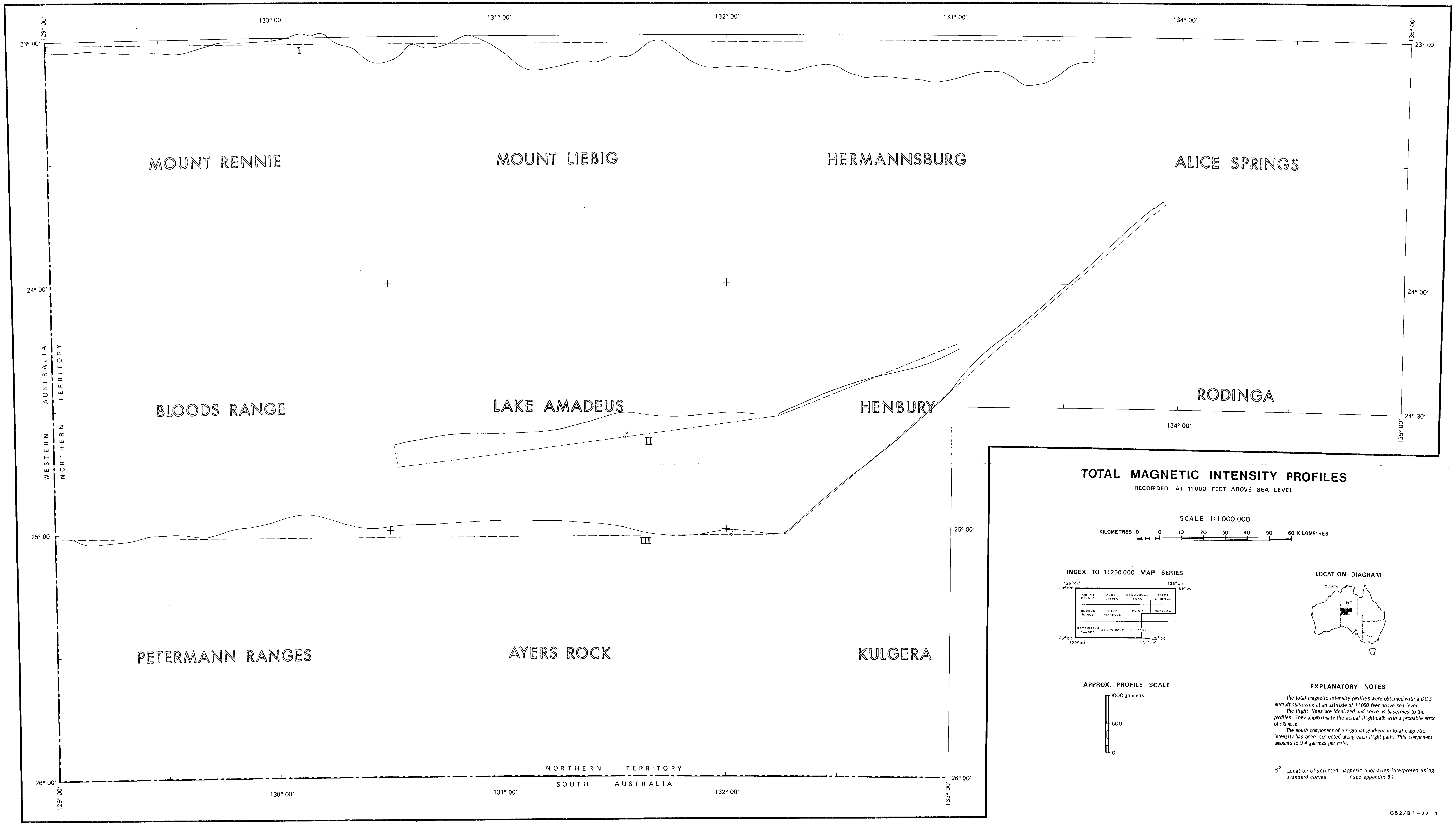
INDEX TO 1:250 000 MAP SERIES

LOCATION DIAGRAM

MAGNETIC CONTOUR INTERVAL 10 GAMMAS

Based on A/80-72

G52/B1-64-1



TOTAL MAGNETIC INTENSITY PROFILES

RECORDED AT 11 000 FEET ABOVE SEA LEVEL

EXPLANATORY NOTES

The total magnetic intensity profiles were obtained with a DC 3 aircraft surveying at an altitude of 11 000 feet above sea level.

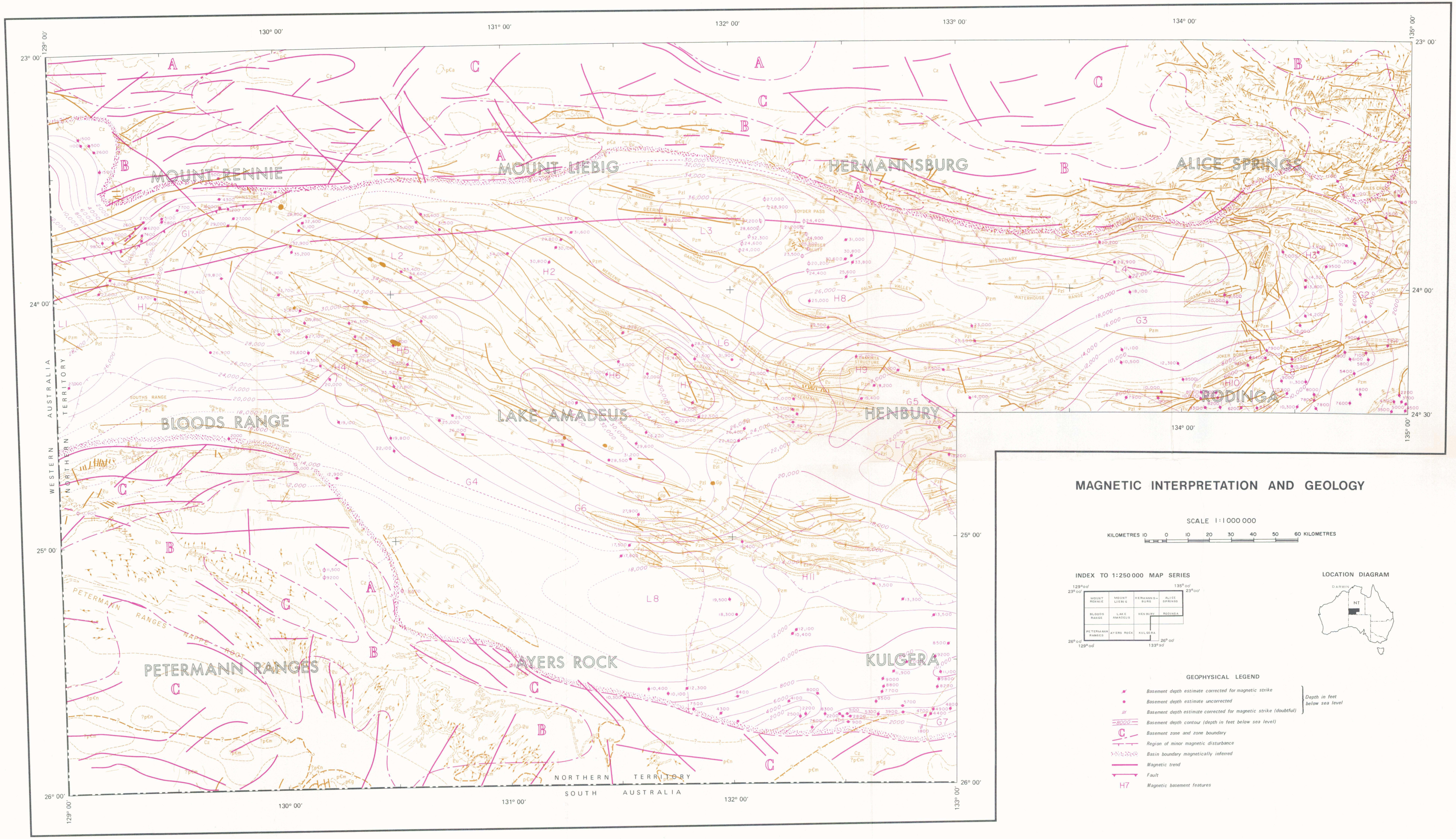
The flight lines are idealized and serve as baselines to the profiles. They approximate the actual flight path with a probable error of ±½ mile.

The south component of a regional gradient in total magnetic intensity has been corrected along each flight path. This component amounts to 9 4 gammas per mile.

o[15] *Location of selected magnetic anomalies interpreted using standard curves (see appendix B)*

G52/B 1-27-1

Based on A/80-72



Based on A/B0-72

MAGNETIC INTERPRETATION AND GEOLOGY

SCALE 1:1 000 000

KILOMETRES 10 0 10 20 30 40 50 60 KILOMETRES

INDEX TO 1:250 000 MAP SERIES

LOCATION DIAGRAM

GEOLOGICAL LEGEND

AGE	SYMBOL	ROCK UNITS
CAINOZOIC	Cz	
MESOZOIC	M	Rumbalara Shale De Souza Sandstone
PERMIAN	Pzu	Crown Point Formation Buck Formation Ligertwood Beds
CARBONIFEROUS		
DEVONIAN	Pzm	Pertnjara Formation; Finke Group
SILURIAN		Mereenie Sandstone
ORDOVICIAN CAMBRIAN	Pzl	Larapinta Group Pertaoorrta Group
UPPER PROTEROZOIC	Ꝑu	Pertatataka Formation; Winnall Beds Areyonga Formation; Inindia Beds; Boord Formation Bitter Springs Formation; Pinyinna Beds Heavitree Quartzite; Dean Quartzite
YOUNGER PRECAMBRIAN	p€	Unnamed; Bloods Range Beds; Mount Harris Basalt
OLDER PRECAMBRIAN	p€n	Olia Gneiss
	p€m	Musgrave–Mann Complex
	p€a	Arunta Complex
	p€q	Quartzite
INTRUSIVE IGNEOUS ROCKS		
PRECAMBRIAN	p€g	Granite

Geological boundary, position approximate
Unconformity
Anticline, showing plunge
Syncline, showing plunge
Overturned anticline
Overturned syncline
Axial trace
Fault
Fault, showing dip of thrust plane; where approximate, line is broken; where inferred, queried

Dip < 15°
Dip 15°–45°
Dip > 45°
Trend lines
(Air–photo interpretation)

Trend of lineation
Strike and dip of foliation (prevailing or unmeasured)
Trend of foliation (with prevailing dip)
Foliation with plunge of lineation

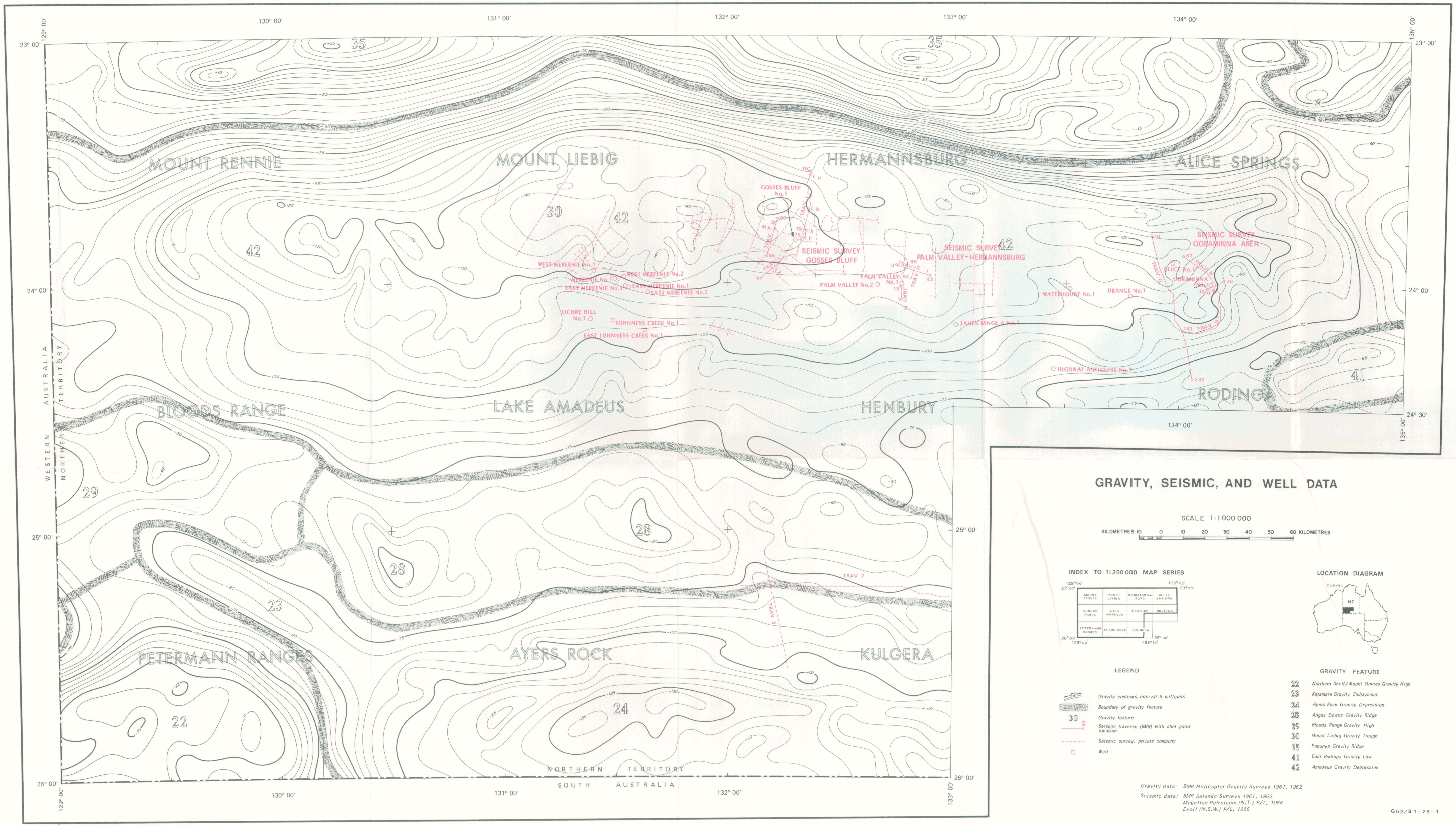
Gp *Mineral occurence; Gp–gypsum*

GEOPHYSICAL LEGEND

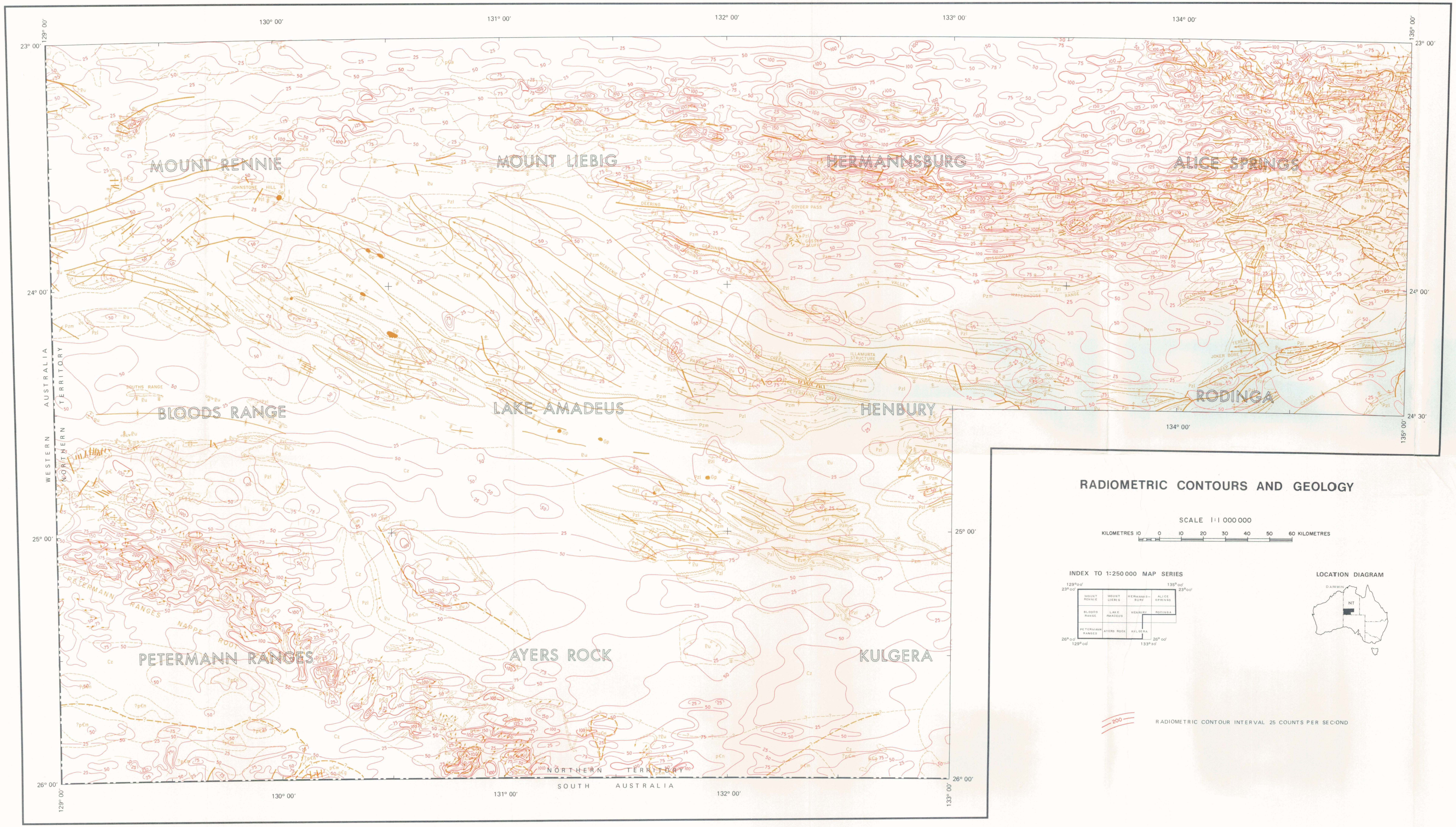
Basement depth estimate corrected for magnetic strike
Basement depth estimate uncorrected
Basement depth estimate corrected for magnetic strike (doubtful)
(Depth in feet below sea level)

8000 *Basement depth contour (depth in feet below sea level)*
C *Basement zone and zone boundary*
Region of minor magnetic disturbance
Basin boundary magnetically inferred
Magnetic trend
Fault
H7 *Magnetic basement features*

G52/B1–28–1



Based on A/BO-72



Based on A/BO-72

GEOLOGICAL LEGEND

AGE	SYMBOL	ROCK UNITS
CAINOZOIC	Cz	
MESOZOIC	M	Rumbalara Shale De Souza Sandstone
PERMIAN CARBONIFEROUS	Pzu	Crown Point Formation Buck Formation Ligertwood Beds
DEVONIAN SILURIAN	Pzm	Pertnjara Formation — Finke Group Mereenie Sandstone
ORDOVICIAN CAMBRIAN	Pzl	Larapinta Group Pertaoorrta Group
UPPER PROTEROZOIC	Ꝑu	Pertatataka Formation; Winnall Beds Areyonga Formation; Inindia Beds; Boord Formation Bitter Springs Formation; Pinyinna Beds Heavitree Quartzite; Dean Quartzite
YOUNGER PRECAMBRIAN	p€	Unnamed; Bloods Range Beds; Mount Harris Basalt
OLDER PRECAMBRIAN	p€n	Olia Gneiss
	p€m	Musgrave-Mann Complex
	p€a	Arunta Complex
	p€q	Quartzite
INTRUSIVE IGNEOUS ROCKS		
PRECAMBRIAN	p€g	Granite

Geological boundary, position approximate
Unconformity
Anticline, showing plunge
Syncline, showing plunge
Overturned anticline
Overturned syncline
Axial trace
Fault
Fault, showing dip of thrust plane; where approximate, line is broken; where inferred, queried

Dip < 15°
Dip 15° – 45°
Dip > 45°
Trend lines
(Dip and trend lines: *Air–photo interpretation*)
Trend of lineation
Strike and dip of foliation (prevailing or unmeasured)
Trend of foliation (with prevailing dip)
Foliation with plunge of lineation

Gp *Mineral occurence; Gp–gypsum*

RADIOMETRIC CONTOURS AND GEOLOGY

SCALE 1:1 000 000

KILOMETRES 10 0 10 20 30 40 50 60 KILOMETRES

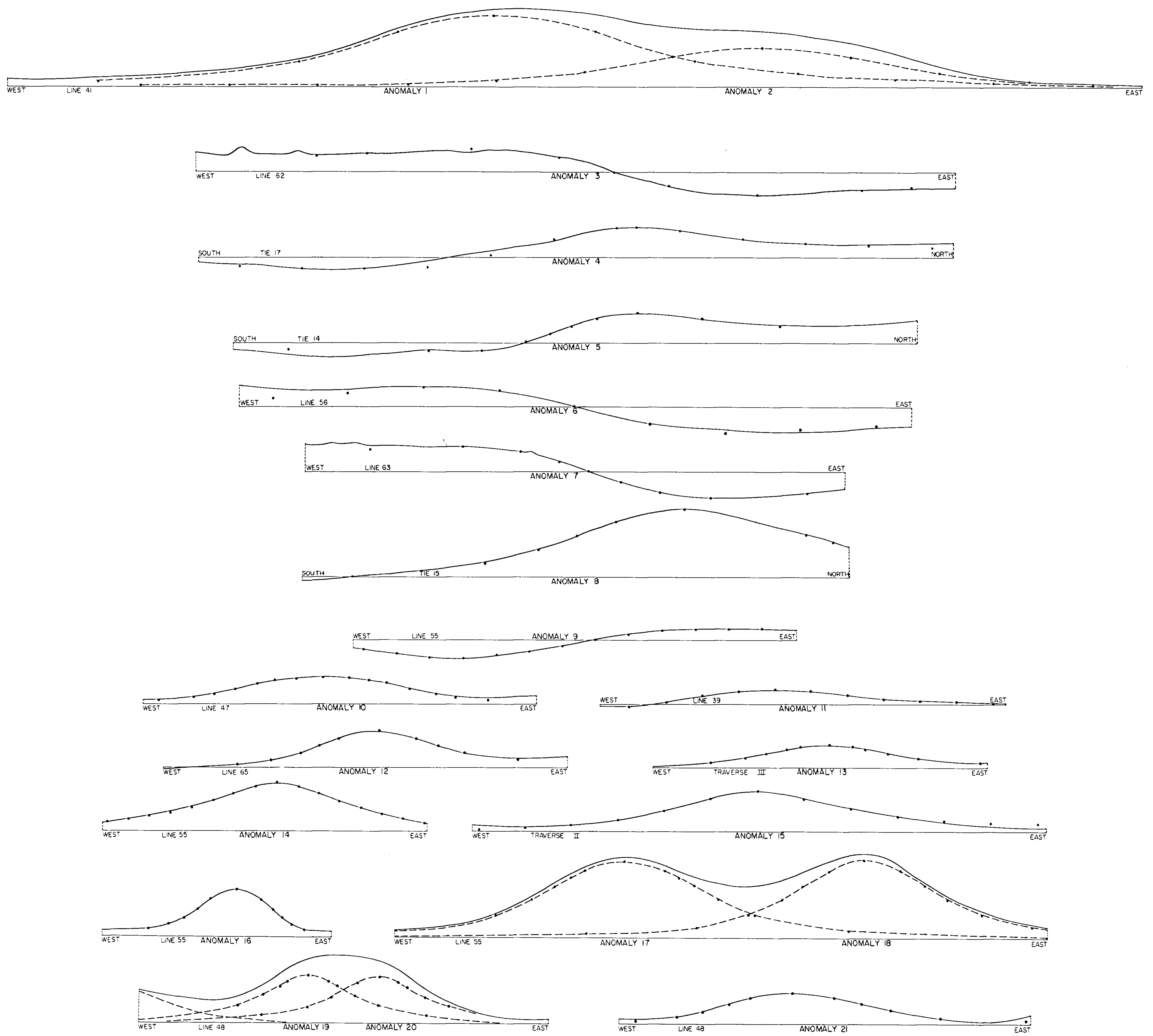
INDEX TO 1:250 000 MAP SERIES

LOCATION DIAGRAM

200 RADIOMETRIC CONTOUR INTERVAL 25 COUNTS PER SECOND

G52/B1-72

WELL LOGS SHOWING GAMMA RADIATION, STRATIGRAPHY, AND LITHOLOGY



LEGEND

- *Original magnetic profile*
- *Theoretical component profile*
- *Point on standard curve*

AIRBORNE SURVEY, AMADEUS BASIN, NT 1965

INTERPRETATION OF SELECTED ANOMALIES USING STANDARD CURVES

EXPLANATORY NOTES

The regional magnetic gradient of 1 gamma per mile west, and 9·7 gammas per mile south have been removed from the original magnetic profiles.
Model parameters are listed in table 1, appendix B.

G52/B1–33 R