COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1966/91

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MOUNT MASSON DETAILED AEROMAGNETIC SURVEY,

NORTHERN TERRITORY 1965

by

D.B. TIPPER and W.A. FINNEY

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ILLUSTRATIONS

Note. This Record supersedes Record No. 1965/220.

1966/91

SUMMARY

Between 18th June and 30th July 1965, the Bureau of Mineral Resources made a detailed aeromagnetic survey of part of the Mount Harris tinfield in the Northern Territory. The area of fifty-five square-miles is centred approximately ninety miles south-east of Darwin. The primary aim of the survey was to assist in the location of further tin lodes.

This Record presents and analyses the aeromagnetic data, and gives a brief account of the geology of the area. The interpretation discusses the dimensions of the bodies producing the anomalies before offering possible mechanisms by which magnetic material became concentrated into those forms. The significance with regard to tin mineralisation is discussed, and finally some deductions on geological structure are given.

A zone of complex magnetic disturbance, three to four miles wide, skirts the Cullen Granite, an intrusion presumably associated with the tin mineralisation. It is suggested that this magnetic pattern is due to a combination of low-grade thermal metamorphism and metasomatism of the surrounding sediments by a lateral extension of the granite beneath the sediments. It is further suggested that, in general, a major rise in magnetic intensity could reflect a local rise in granite level, and therefore indicate an area where tin prospects are increased.

Recommendations for follow-up work include a ground inspection of the magnetic bodies where they reach the surface, to test these suggestions, and subsequently a detailed sampling programme of one of the regions whose magnetic character is very similar to that detected over the largest tin mine in the area.

1. INTRODUCTION

In 1963, an aeromagnetic reconnaissance survey was flown in the Darwin/Pine Creek region of the Northern Territory (Goodeve, in preparation). The survey covered the Mount Bundey and Burrundie and parts of the Marrakai, Batchelor, Wool Wonga, and Ban Ban 1:63,360 map areas (Plate 1). From an examination of the results, three small areas were selected for more detailed aeromagnetic investigation, and the first of these areas, around Mount Bundey, was flown in 1964 (Milsom & Finney, 1965).

Between 18th June and 30th July 1965, the Bureau of Mineral Resources (BMR) flew the second of the selected areas in the vicinity of Mount Masson. The locality and extent of the area is shown in Plate 1; it covers 55 square miles and forms the major part of the Mount Harris tinfield. This Record presents and analyses the aeromagnetic data.

The primary aim of the survey was to assist in the location of tin-bearing bodies or extensions of existing lodes. It was considered that this might be achieved by evaluating the geological structure of the area. Of secondary importance was the testing of the detailed magnetic method in an area of considerable magnetic disturbance and of some geological complexity.

Geological mapping of the area was begun in 1954 during preparation of the Ban Ban geological sheet. In 1957, the geology of the Mount Harris leases was mapped on a scale of 1 inch to 100 feet by officers of the BMR Resident Geological Staff, Darwin. The data compiled were used in a map published at a scale of one inch to 200 feet in a preliminary report on the Mount Harris tinfield (Hays, 1958). Further work, completed in 1958, included remapping of the whole of the eastern half of the Ban Ban area. The resultant geological map (Hays, 1960) was used as a base for Plate 2, and the geology given in Section 2 was derived from this work. Explanatory notes to accompany the Pine Creek 1:250,000 geological sheet were published in 1962 (Malone, 1962).

Apart from the aeromagnetic reconnaissance survey, (Goodeve, in preparation) the only known previous geophysical investigations in the survey area are three ground magnetic traverses in the vicinity of Jessop's lode (Vanderplank, , 1964), which were surveyed to test for any immediately noticeable association between mineralisation and magnetic intensity. The results were not conclusive. The results of the part of the aeromagnetic reconnaissance survey that is relevant to the detailed survey are discussed in Section 3.

2. GEOLOGY

An account of the geology of the Mount Harris tinfield has been given by Hays (1958 & 1960). Only a broad outline is given here and this is derived from Hays' later work.

The greater part of the area consists of arenaceous and argillaceous sediments of Lower Proterozoic age, which have been severely folded into a broad anticlinorium. The folding was accompanied by faulting and fissuring. Subsequently, the eastern flank of the anticlinorium was intruded by a large granite body causing local thermal metamorphism. Completion of the orogenic cycle was followed by faulting of unknown age along the granite/sediment contact. Miocene peneplanation was succeeded by a recent cycle of erosion. Cassiterite mineralisation, presumably associated with the granite, was introduced into faults and fissures developed before granite intrusion.

Stratigraphy

The Lower Proterozoic Masson Formation, a series of interbedded arkose, quartzite, greywacke, and slate, occupies most of the survey area. It has been divided into three arenaceous and two argillaceous divisions, each of which consists of interbedded arenites and lutites. The total thickness has been estimated as being between 6000 and 12,000 feet. The arenaceous sediments are basically quartz and feldspar grains cemented by quartz and iron. Chlorite and sericite have been seen in some specimens. The argillaceous sediments are red and buff banded slates in outcrop and black graphitic pyritic slates in the unweathered state. Close to the granite contact, the argillaceous sediments have been metamorphosed to cordierite- and andalusite-hornfelses. All specimens petrologically examined by Walker (Hays, 1960) contain iron ore, and one specimen contains grains of pyrrhotite.

Two small regions of outcropping Golden Dyke Formation are mapped at the north-western periphery of the area. This formation, which conformably overlies and intercalates with the Masson Formation, is rich in iron. The basal beds are intimately associated with basic intrusives, thought to be altered quartz-dolerite sills. It has been suggested by Hays that these are spilitic, but this view is not supported by Bryan (1962). Thin sections of these intrusives show the presence of small amounts of ilmenite and hydrated iron oxide. A few small outcrops of altered quartz dolerite have been mapped within the Masson Formation sequence. These possibly represent either a feeder dyke to the sills in the Golden Dyke Formation, or one of the same suite. Small granules of black iron ore are evident in thin sections described by Morgan (Hays, 1960). The presence of magnetite and ilmenite is shown by their alteration products, leucoxene and hydrated iron oxide.

A lobe of the intrusive Cullen Granite crops out just within and to the south-east of the survey area. Its mean composition is 60% feldspar, 25% quartz, and 15% ferromagnesian minerals. The metamorphic aureole is described as very narrow (of the order of 300 feet) and discontinuous. No chilled margin has been recognised.

The most extensive superficial deposit is ferricrete, which crops out in every flat-bottomed valley, and which attains a maximum thickness of 20 feet. The ferricrete is overlain by a discontinuous veneer of alluvium with an average thickness of 6 feet in the Mary River.

Structure

Folding. The area includes the western limb and perianticline of a major anticlinorium, the Masson Anticline. The axis of the main anticline lies a few hundred yards west of the western margin of the granite, and strikes and plunges to the north-north-west with an angle of plunge of about 30°. On the western limb of the Masson Anticline, large subsidiary folds having widths in outcrop of up to half a mile have axes parallel to the main fold axis. A few subisdiary folds are isoclinal with dips vertical or steep to the west, and shearing may occur in the axial zones. In the incompetent beds, intense drag-folding has occurred in the axial zones and along the limbs of the subsidiary folds. Individual drag-folds range in width from one inch to 200 feet. Where the folded strata consist of alternating hard and soft bands, brecciation is common.

All the argillaceous beds have a well-developed vertical slaty cleavage, with a strike parallel to the fold axial planes. This cleavage is therefore thought to be the result of folding.

Faulting and minor fractures. Although there is considerable indirect evidence of faulting, only one fault is regarded as established. This strikes south-west along the line of Adam Creek, and then appears to form the boundary of the granite for more than a mile, before fading out one mile north-west of Mount George mine. A cross-fault striking N 70^{O}E is suggested by a three-mile-long fault-line scarp west of the Adam Creek Fault.

The boundary of the Cullen Granite is thought to be extensively faulted. Alluvial cover over the contact in the north-east of the area conceals the nature of this faulting, but the remainder of the contact zone in the area is marked by fault or fault-line scarps, by the discontinuous metamorphic aureole, and by continuous lines of barren quartz veins. Other evidence for faulting is the absence of a chilled margin to the granite.

Several large meridional quartz veins, extending for several miles south of Mount George mine, are seen as a possible strike fault. The Mount Masson mine and Jessop's lode are situated on a sinuous photo-geological feature several miles long, which trends generally north and is marked by quartz-haematite breccias. This and a parallel feature one mile to the west may also be strike faults.

At least two sets of near-vertical joints have been observed throughout the area bearing N 160^{O}E and N 80^{O}E, the former probably produced during folding.

Tin mineralisation

Nature of the lodes. The area contains many brecciated quartz-iron lodes of various types. By a sampling of all those mapped, Hays divided the lodes into two groups with a zonal distribution related to the margin of the granite. The outer zone, coinciding with the area underlain by the Golden Dyke Formation, is virtually barren. The inner zone, wholly within the Masson Formation, is three miles wide and borders the granite. It constitutes the greater part of the survey area.

At least three types of lode have been recognised. Lodes of the first type are associated with drag-folding, the iron and quartz having migrated into axial areas during folding. They contain little or no tin. Lodes of the second type are not obviously related to drag-folding and have a constant trend parallel to the axis of the Masson Anticline. These probably formed in tension gashes produced during folding, and include many of the Mount Harris lodes. The Mount George lodes could also occupy tension gashes but were probably produced by granite intrusion rather than by folding. The Mount Masson and Jessop's lodes represent the third type and lies along the northerly-trending photo-geological feature. This might be a large shatter belt, but the Mount Masson lode could be a mineralised fault breccia formed in a strike fault.

Metallogenesis. All the lodes examined by Hays are brecciated, the breccias consisting of angular fragments of vein quartz and country rock, cemented by limonite and haematite. He has summarised the sequence of events in the formation of the mineralised breccias, as follows:

(a) Fissure formation. The fissures are related to the main folding, to pre-granite faulting and to granite intrusion.

(b) Mineralisation. It may be supposed that there is a genetic relationship between granite intrusion and mineralisation.

(c) Brecciation.

(d) Ferruginisation of unknown age.

3. RESULTS AND INTERPRETATION

Results

The aeromagnetic data are presented in Plate 2 as a contour map of total magnetic intensity at a scale of 1:30,030 and with a basic contour interval of 10 gammas. Corrections have been made for the diurnal variation of the total field, but the Earth's regional gradient has not been removed. The intensity values shown are relative only and are referred to an arbitrarily chosen datum.

It will be seen by comparing Plates 2 and 4, that the general magnetic pattern determined by the 1963 reconnaissance survey is well reflected by the results of the detailed survey. However, this pattern is now revealed in far greater detail. The reduced ground clearance has increased anomaly resolution, and single magnetic 'highs' are resolved into a series of separate maxima. In addition, the closer line-spacing has enabled the north-south extent of anomalies to be defined with greater accuracy, and other anomalies from sources of small areal extent have been detected.

Interpretation

The magnetic pattern is a series of sub-linear anomalies. The average amplitude is approximately 500 gammas but larger amplitudes up to 1700 gammas were detected. These relatively major 'highs' and their associated 'lows' have superimposed upon them numerous minor magnetic features, many of which are revealed only as a slight nosing of the contours. The entire pattern froms a zone of complex disturbance, which skirts the Cullen Granite and extends three or four miles into the sedimentary sequence from the granite/sediment contact as mapped at the surface. This contact is characterised by a sharp drop in intensity towards the granite, which therefore has a relatively low magnetic susceptibility.

The more dominant magnetic trends have been delineated in Plate 3. West of the road from Jessop's lode to Mount George mine and Lucy mine, these trends are parallel to the general strike of the bedding, to quartz and quartz-haematite veins, and to tin lodes. In the south-west, west, and north-west of the area, all features trend north, whereas in the south-east both the magnetic trends and the geological features strike north-north-west. East of the Adam Creek Fault, a similar correlation is seen. On the western side of the Mount Harris leases, all features including the magnetic trends strike north-north-east, and on the eastern side, all strike north-north-west.

West of the Mount Harris leases, between the Jessop's lode/Mount George mine road and the Adam Creek Fault, the magnetic trends cross the bedding-strike at a large angle and appear to have been controlled in a direction parallel to the faulting.

Although a correlation has been found between the magnetic pattern and the general geological strike, there is no obvious association between the anomalies and particular stratigraphic horizons or lithologies, as mapped at the surface. Anomalies of high amplitude were detected over both the argillaceous and arenaceous divisions of the Masson Formation. It is of interest that the highest anomaly in the area (crossed by section Q-Q') was detected over rock mapped as granite. As will be shown later, this anomaly is almost certainly due to an unmapped body of metamorphosed sediments. A similar body (crossed by section T-T') was detected about two miles to the west-north-west.

Selected major anomalies have been quantitatively analysed to provide information on the depths of burial and widths of the bodies. Plate 3 shows a series of lines, A-A', B-B', etc. where a magnetic profile was constructed from the contour map, normal to the magnetic strike of the anomaly. Depths were obtained by the interpretational method of Peters (1949), which is outlined in Appendix 2.

For convenience of presentation, the data obtained are tabulated in Table 1, (page 6).

The depth determinations are given to the nearest 50 feet, and the half-widths to the nearest 100 feet. Their accuracy is considered to be ±20%. The depth determinations do not agree with those calculated from the reconnaissance survey data, but the former are considered more reliable as they were derived from a more detailed survey. In general, the dip of the bodies is near-vertical, but magnetic interference from adjacent anomalies does not permit the accurate determination of dip angles.

Where calculations have been made at different sections of the same anomaly, e.g. at B-B', C-C', and D-D', the results are consistent within themselves. The body in question is seen to deepen to the south whilst the half-width remains reasonably constant.

Calculations for the susceptibility of the bodies ranged from 3×10^{-3} to 7×10^{-3} CGS units. The average figure of 5×10^{-3} CGS units is equivalent to a rock containing approximately either 1% magnetite or 4% pyrrhotite.

The magnetic data and the interpretation thus far discussed can be analysed by reference to geological concepts. Clearly, as Goodeve (in preparation) has already stated, the disposition of magnetic disturbance over the Masson Formation shows that the granite was associated with the creation of this disturbance. He postulated that the belt of disturbance reflects the lateral extent of the granite beneath the sediments. Initially, there appears to be at least four mechanisms by which concentrations of magnetic material could have formed beneath outcropping Masson Formation:

(1) A basic derivative of the granite.
(2) Thermal metamorphism of basic rocks.
(3) Thermal metamorphism of the sediments.
(4) Thermal metamorphism and superimposed metasomatism of the sediments.

Basic derivative. In many intrusions, a process of magnetic differentiation has occurred through fractional crystallisation of the magma, allowing the heavier, more basic crystals of early formation to accumulate by gravitative sorting to form a basic derivative at depth. Although susceptibility calculations support this concept, such a process in the survey area is considered unlikely. The magnetic intensity over the outcropping granite is relatively low, and also there is insufficient evidence of tectonic forces of the magnitude required to displace the basic derivatives to the side of the granite outcrop.

Thermal metamorphism of basic rocks. Hays (1960) and Bryan (1962) have each discussed the occurrence of altered quartz-dolerite sills in the Golden Dyke and Masson Formations, and Hays has suggested that they are spilitic. It is known that spilitic rocks are usually found in close geographic association with ultrabasic intrusives. Although no ultrabasics have been observed in the area, the possibility of their occurrence should not be discounted. Metamorphism of these could account for the disposition of the magnetic anomalies around the granite and also for the high susceptibility values. The presence of ultrabasics is, however, considered unlikely as they would be expected to show some magnetic effect outside the radius of influence of the granite.

TABLE 1

Interpreted dimensions of magnetic bodies

Anomaly section	Depth to top of the body below the surface (in feet)	Half-width of the body (in feet)
A-A'	100	800
B-B'	200	1200
C-C'	300	1000
D-D'	350	1100
E-E'	150	700
F-F'	50	200
G-G'	200	700
H-H'	100	600
I-I'	300	700
J-J'	800	600
K-K'	350	1000
L-L'	650	1100
M-M'	350	1000
N-N'	350	1000
O-O'	00	300
P-P'	700 (doubtful)	1200
Q-Q'	50	800
R-R'	600	1200
S-S'	150	of the order of 2000
T-T'	00	600
U-U'	350	1000

<u>Thermal metamorphism of the sediments</u>. The Masson Formation consists of pyritic graphitic slates and iron-cemented quartz-feldspar arenites. Morgan (Hays, 1960) has petrologically examined specimens of pelitic rocks from the Masson mine shaft and almost all contain hydrated iron oxide. It is known that any haematite or limonite in a sedimentary sequence subjected to low-grade thermal metamorphism will readily be reduced to magnetite (Harker, 1950). It is possible that the magnetite so produced has been reoxidised to haematite and limonite at the surface. However, it is also possible that the limonite seen in the specimens was derived from the pyrite in the Masson Formation, in which case thermal metamorphism of the sulphide would not cause any alteration to magnetic iron. The arenaceous divisions of the Masson Formation are known to be partially cemented by iron. Harker also states that if a sandstone with a ferruginous cement is subjected to thermal metamorphism, the iron, whether limonite or haematite, is readily reduced to magnetite. Walker (Hays, 1960), describing thin slides of the metamorphosed arenaceous Masson Formation, mentions the occurrence of iron ore but does not name the specific mineral.

<u>Metamorphism and metasomatism of the sediments</u>. The most probable explanation for the magnetic pattern is a combination of low-grade thermal metamorphism, discussed above, and superimposed metasomatism. Tin mineralisation is believed to be a hypothermal process (Lindgren, 1933). Lindgren lists a number of minerals commonly associated with high-temperature replacement deposits. These minerals, which include magnetite, pyrrhotite, and ilmenite, the three most magnetically susceptible, are those found in varying proportions as associates of cassiterite. Below the weathered zone, these mineral assemblages could account for the small anomalies superimposed on the major magnetic 'highs'.

It is possible that both thermal metamorphism and metasomatism have a bearing on tin mineralisation. Thermal metamorphism would suggest an association between magnetic anomalies, the grade of metamorphism, and therefore possibly the depth of burial of the granite. This could be of great use in the location of tin lodes. Many writers have described the formation of tin as the infilling by the residual and more acid differentiate of the parent granite magma. Of extreme interest is the order of deposition of the minerals. Jones (1925) states that the minerals in tin lodes are distributed with a certain amount of regularity in relation to both their vertical and horizontal distances from the granite rocks from which the mineralising fluids emanated. Further, tin is invariably found extremely close to the granite body, decreasing in concentration upwards. Thus, if the magnetic disturbance may be correlated with the depth of burial of the granite, an association may also be postulated between magnetic 'highs' and areas of increased tin prospects. Both thermal metamorphism and metasomatism indicate therefore, that high magnetic values should be detected over concentrations of tin.

An inspection of the contour map (Plate 2) shows that in the survey area, a correlation does exist between magnetic 'highs' and economic tin lodes. Both the Mount Masson mine and Jessop's lode lie very close to the axis of a major anomaly that trends north, approximately parallel to the geological strike and to known quartz and quartz-haematite veins. Similarly, the Mount George mines are situated on the flank of a magnetic anomaly. This anomaly forms a series of parallel maxima trending north to north-north-west parallel to the strike and to quartz veins. Of the Mount Harris leases, only Nelson No. 1 mine is not close to a magnetic 'high'. This correlation supports the hypothesis of combined metamorphism and metasomatism. Other data consistent with the theory are -

(1) The magnetic trends are parallel to the bedding, suggesting that original lithological variations have had a controlling influence on the magnetic pattern.

(2) The highest anomaly is found over what is mapped as granite, but which is probably an unmapped roof pendant.

(3) The belt of disturbance parallels the sediment/granite contact and, away from the granite, the Masson Formation is non-magnetic.

Although original lithological variations in the sediments would have been a factor controlling the grade of metamorphism, and therefore the magnetic susceptibility, it is probable that many of the magnetic anomalies indicate localised areas where granite is nearer the surface. On this basis, a line on the flank of an anomaly representing the position of steepest magnetic gradient would also represent either a fault or the approximate boundary of an unfaulted granite cupola. It is seen that a number of faults mapped by Hays coincide with the line of steepest gradient. The large meridional anomaly in the south-west of the area is approximately defined by two faults inferred from geological observations (Plate 2).

The marked difference in the magnetic patterns on either side of the lines of the inferred faults, particularly the eastern one, suggests that this fault does in fact exist. The shear zone east of the Mount Harris leases is similarly defined by a band of closely spaced contours. The Adam Creek Fault north of the granite has little magnetic expression, but the cross-fault postulated by Hays (Plate 2) appears on magnetic evidence to extend north-eastwards through the centre of the Mount Harris leases.

The magnetic data are generally consistent with the theory of a faulted sediment/granite contact, advocated by Hays, but a similar pattern could be expected from an unfaulted contact between a relatively non-magnetic granite and a sedimentary sequence metamorphosed by that granite. In both cases, if the dip of the contact is steep, the magnetic field would be expected to rise sharply along a traverse from the granite on to the metamorphics. The pronounced 'lows' just south of the northern extremity of the granite are not due to any intra-granite feature, but reflect the high surface density of negative magnetic poles induced on the south-facing limiting plane of the sediments at their contact with the granite. The contact between one and two miles north of Mount George mine is interesting. The presence of hornfelses is indicated in the geological map where there is no corresponding major magnetic 'high'. It is believed that at this locality the dip of the contact is at a small angle, such that only a thin veneer of metasediments overlies the granite. In this way, the negative magnetic poles induced at the base of the sequence would largely cancel the positive poles induced at the top.

The abrupt change in magnetic trend direction from north to north-east, in the central part of the area, may indicate a fault along the line of the Mount Masson road from the north-west corner of the granite outcrop. A fault trending east-south-east from Nelson No. 1 mine is suggested by a change in magnetic character and trend direction either side of the fault. Two cross-faults in the south-eastern corner of the area are deduced from changes in magnetic character and the co-linear termination of a number of anomalies. Similar evidence was found for the Adam Creek Fault west of the road from Jessop's lode to Mount George mine. An east-west fault in the extreme north-west corner of the area is suggested by an abrupt displacement of the contour lines.

No inferences could be drawn on folding in the area, as those folds that are known to exist have no obvious magnetic expression.

4. CONCLUSIONS AND RECOMMENDATIONS

A process of low-grade thermal metamorphism and metasomatism is considered responsible for the observed magnetic pattern. As a corollary to this, the major magnetic 'highs' possibly reflect the shallowness of the Cullen Granite beneath the Masson Formation. A correlation is therefore suggested between the position of magnetic 'highs' and the more favourable locations for tin mineralisation. No association is implied, however, between the amplitude of the anomalies and either the grade of tin or its reserves.

All tin mined to date has been found near a confirmed or postulated fault, and the area for further investigation would seem to be where a magnetic 'high' occurs near faulting. It is recommended that a surface anomaly crossed by section T-T' be first inspected to determine whether or not it is due to a metamorphosed roof-pendant. The anomaly crossed by Q-Q' should also be investigated. If the occurrence of metamorphism is verified, sampling traverses and possibly drilling of the major anomalies would be justified. The most interesting area to commence investigations would be the large anomaly crossed by sections B-B', C-C' and D-D'. This anomaly is due to a body at a depth similar to that of the orebody at the Mount Masson mine. A second area worthy of ground inspection is the anomaly crossed by section F-F', which is due to a body at very shallow depth, situated extremely close to a postulated fault.

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APPENDIX 1

Operational Details

Survey specifications

Ground clearance	:	Generally 380 feet
Detector altitude	:	Generally 350 feet above ground level
Line spacing	:	One-tenth of a mile
Line orientation	:	West
Area surveyed	:	55 square miles

Equipment

Aircraft	:	Cessna 180
Magnetometer	:	MNS-1 proton precession type of BMR design
Recorders	:	1 single-channel Mosely-Autograf, sensitivity 100 gammas full-scale. 1 two-channel Devar, sensitivity 10,000 gammas full-scale
Camera	:	Modified Vinten, frame type, 35 mm., with 186° fish-eye lens
Radio-altimeter	:	AN/APN-1 coupled to the Devar recorder
Storm warning detector	:	MFD-3 fluxgate type of BMR design coupled to an Esterline-Angus recorder, sensitivity 100 and 200 gammas full-scale

Method

A correction for diurnal variation was determined by flying a pre-selected baseline at the beginning and end of each flight. The baseline was chosen for its ease of precise reflying and relatively flat magnetic field. Each baseline profile was compared with a reference or standard profile, and the diurnal correction was applied by assuming that the variation was linear throughout the flight. This assumption was checked daily by reference to a ground magnetometer, which was also used as a magnetic-storm warning device.

The magnetometer records that were accepted as survey data showed an average noise envelope of 15 gammas, and profile smoothing was required throughout.

Flight-path recovery was made by plotting terrain features from the 35-mm film on to aerial photographs and then on to a photoscale planimetric base map. 1100 control points were plotted for approximately 600 flight-line miles. The aircraft's ground speed was assumed constant between any two adjacent control points. The maximum probable error is estimated as ± 150 feet.

Personnel

The BMR personnel engaged on the survey were D. B. Tipper, W. A. Finney, A. Crowder, A. S. Scherl, J. Boyd, A. E. Busuttil and I. Heath. The Trans-Australia Airlines pilot was First Officer J. Lord.

APPENDIX 2

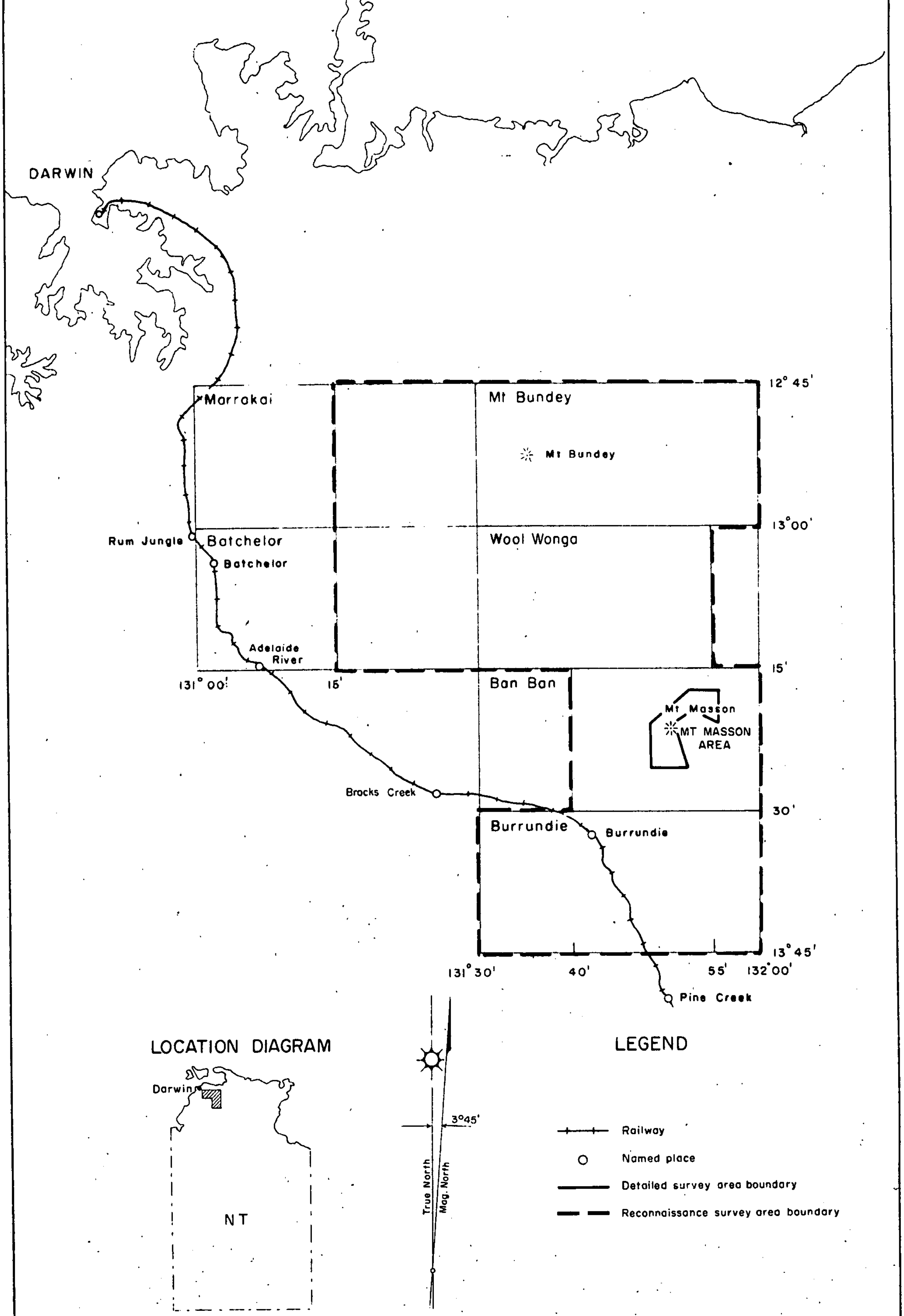
Interpretation Methods

The half-maximum-slope method (Peters, 1949) was used to obtain determinations of depth to the magnetic bodies. Anomaly profiles were drawn from the contour map along sections A-A', B-B', etc. normal to the magnetic strike. The depth (r) of the body below the detector was obtained by using a Peters' factor of 1.6. The width of the body (2b) was obtained from the distance between the two points of inflexion on the profiles. By evaluating the ratio b/r, more appropriate Peters' factors were found from graphs of b/r against σ/r, constructed from data given by Moo (1965).

The new value of Peters' factor gave a more accurate determination of r, and by subtracting h (the aircraft's ground clearance, obtained from the radio-altimeter record), the value of d (depth of burial) wasobtained.

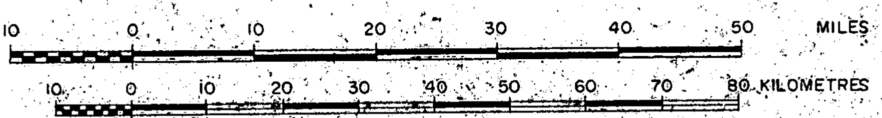
It is recognised that the magnetic bodies probably do not fully comply with the basic assumptions laid down by Peters on the idealised geometric shape of dyke-like bodies. For this reason, the accuracy of the calculations is given as ± 20%.

PLATE I



DETAILED AEROMAGNETIC SURVEY, MOUNT MASSON, NT 1965

LOCALITY MAP



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B1-27

To Accompany Record No. 1966/91

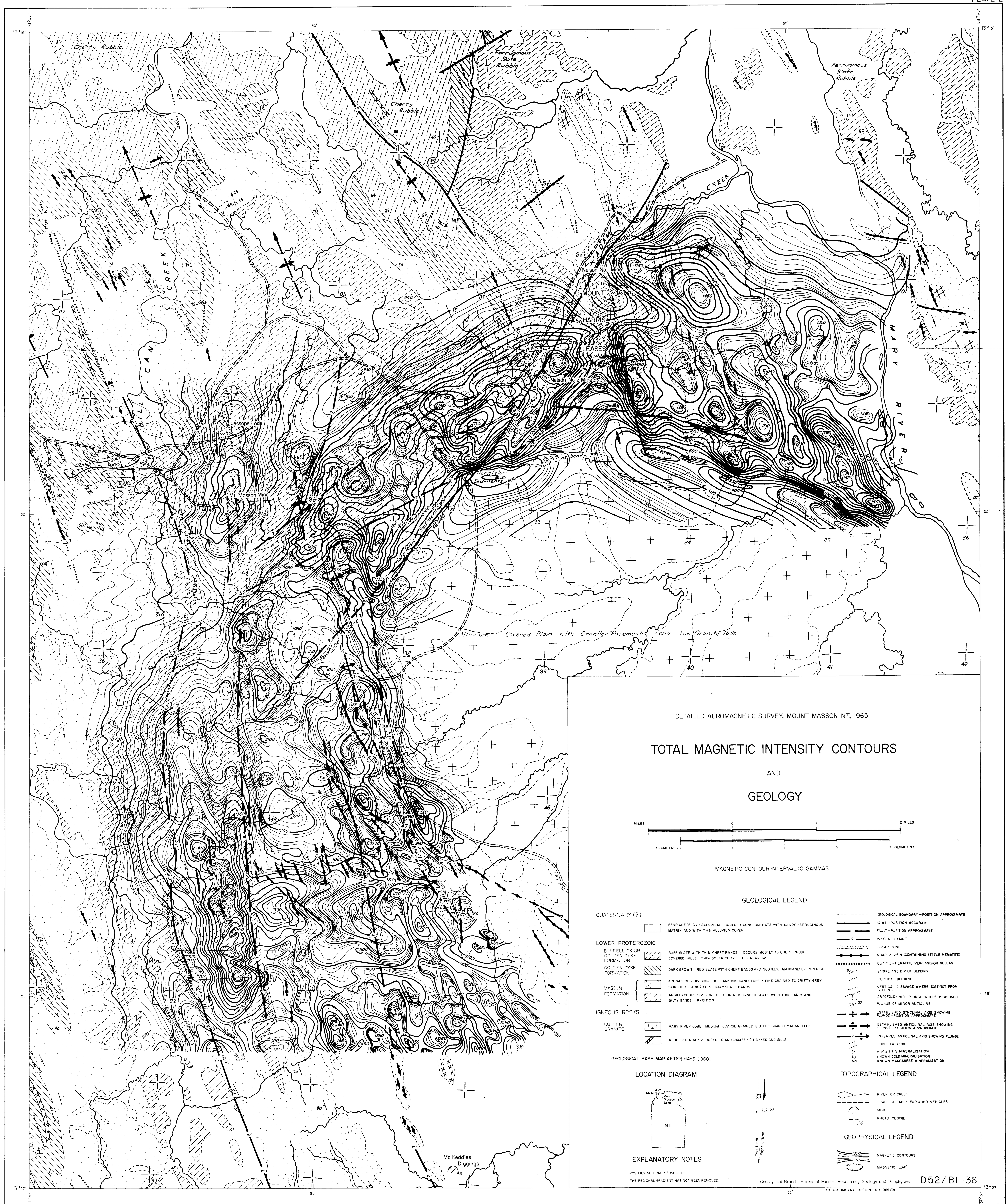
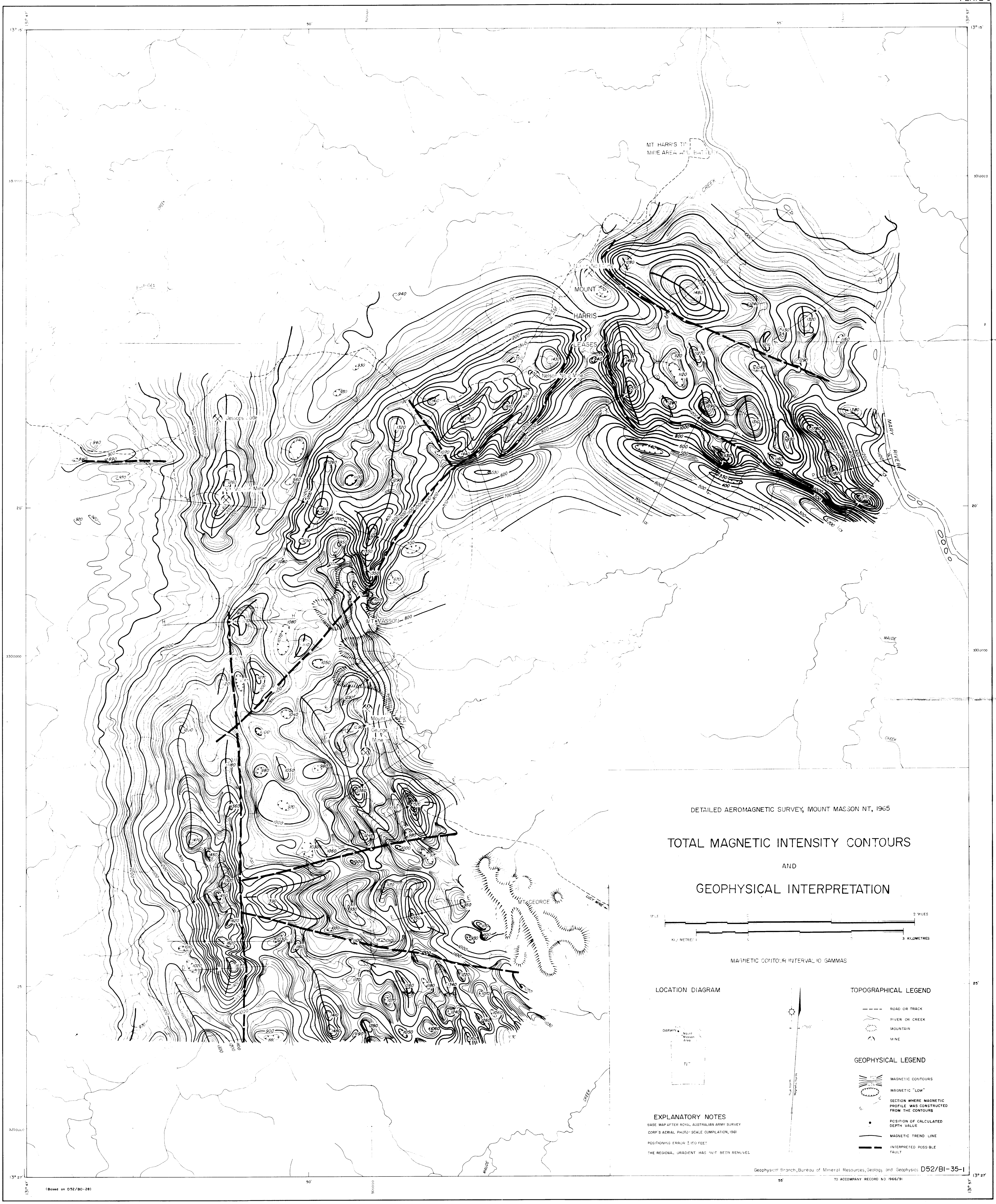

DETAILED AEROMAGNETIC SURVEY, MOUNT MASSON NT, 1965
TOTAL MAGNETIC INTENSITY CONTOURS
AND
GEOLOGY
MILES 1 0 1 2 MILES
KILOMETRES 1 0 1 2 3 KILOMETRES
MAGNETIC CONTOUR INTERVAL 10 GAMMAS
GEOLOGICAL LEGEND
QUATERNARY (?)
FERRICRETE AND ALLUVIUM. BOULDER CONGLOMERATE WITH SANDY FERRUGINOUS MATRIX AND WITH THIN ALLUVIUM COVER.
LOWER PROTEROZOIC
BURRELL CK OR GOLDEN DYKE FORMATION
BUFF SLATE WITH THIN CHERT BANDS - OCCURS MOSTLY AS CHERT RUBBLE COVERED HILLS. THIN DOLERITE (?) SILLS NEAR BASE.
GOLDEN DYKE FORMATION
DARK BROWN - RED SLATE WITH CHERT BANDS AND NODULES. MANGANESE/IRON RICH.
MASSON FORMATION
ARENACEOUS DIVISION. BUFF ARKOSIC SANDSTONE - FINE GRAINED TO GRITTY GREY SKIN OF SECONDARY SILICIA - SLATE BANDS.
ARGILLACEOUS DIVISION. BUFF OR RED BANDED SLATE WITH THIN SANDY AND SILTY BANDS - PYRITIC ?
IGNEOUS ROCKS
CULLEN GRANITE
MARY RIVER LOBE. MEDIUM - COARSE GRAINED BIOTITIC GRANITE - ADAMELLITE.
ALBITISED QUARTZ DOLERITE AND DACITE (?) DYKES AND SILLS.
GEOLOGICAL BOUNDARY — POSITION APPROXIMATE
FAULT - POSITION ACCURATE
FAULT - POSITION APPROXIMATE
INFERRED FAULT
SHEAR ZONE
QUARTZ VEIN (CONTAINING LITTLE HEMATITE)
QUARTZ - HEMATITE VEIN AND/OR GOSSAN
STRIKE AND DIP OF BEDDING
VERTICAL BEDDING
VERTICAL CLEAVAGE WHERE DISTINCT FROM BEDDING
DRAGFOLD - WITH PLUNGE WHERE MEASURED
PLUNGE OF MINOR ANTICLINE
ESTABLISHED SYNCLINAL AXIS SHOWING PLUNGE - POSITION APPROXIMATE
ESTABLISHED ANTICLINAL AXIS SHOWING PLUNGE — POSITION APPROXIMATE
INFERRED ANTICLINAL AXIS SHOWING PLUNGE
JOINT PATTERN
Sn KNOWN TIN MINERALISATION
Au KNOWN GOLD MINERALISATION
Mn KNOWN MANGANESE MINERALISATION
GEOLOGICAL BASE MAP AFTER HAYS (1960)
LOCATION DIAGRAM
DARWIN
Mount Masson Area
NT
True North
Magnetic North
3°50'
TOPOGRAPHICAL LEGEND
RIVER OR CREEK
TRACK SUITABLE FOR 4 W.D. VEHICLES
MINE
PHOTO CENTRE
GEOPHYSICAL LEGEND
MAGNETIC CONTOURS
MAGNETIC 'LOW'
EXPLANATORY NOTES
POSITIONING ERROR ± 150 FEET.
THE REGIONAL GRADIENT HAS NOT BEEN REMOVED.
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.
D52/B1-36
Cherty Rubble
Ferruginous Slate Rubble
Cherty Rubble
Ferruginous Slate Rubble
BILL CAN CREEK
CREEK
MARY RIVER
Nelson No. 1 Mine
MOUNT
HARRIS
LEASES
Nelson No. 2 Mine
Jessops Lode
Mt. Masson Mine
Hornfelsic Sediments
Fault Line Scarp
Alluvium Covered Plain with Granite Pavements and Low Granite Hills
Mount George Mine
Mc Keddies Diggings
TO ACCOMPANY RECORD NO 1966/91

PLATE 3



DETAILED AEROMAGNETIC SURVEY, MOUNT MASSON NT, 1965
TOTAL MAGNETIC INTENSITY CONTOURS
AND
GEOPHYSICAL INTERPRETATION
2 MILES
3 KILOMETRES
MAGNETIC CONTOUR INTERVAL 10 GAMMAS
LOCATION DIAGRAM
DARWIN
Mount Masson Area
True North
Magnetic North
TOPOGRAPHICAL LEGEND
ROAD OR TRACK
RIVER OR CREEK
MOUNTAIN
MINE
GEOPHYSICAL LEGEND
MAGNETIC CONTOURS
MAGNETIC "LOW"
SECTION WHERE MAGNETIC PROFILE WAS CONSTRUCTED FROM THE CONTOURS
POSITION OF CALCULATED DEPTH VALUE
MAGNETIC TREND LINE
INTERPRETED POSSIBLE FAULT
EXPLANATORY NOTES
BASE MAP AFTER ROYAL AUSTRALIAN ARMY SURVEY
CORP'S AERIAL PHOTO-SCALE COMPILATION, 1961
POSITIONING ERROR ± 150 FEET
THE REGIONAL GRADIENT HAS NOT BEEN REMOVED
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B1-35-1
TO ACCOMPANY RECORD NO. 1966/91
(Based on D52/B0-28)
MOUNT
HARRIS
LEASES
MT. HARRIS TIN MINE AREA
Nelson No 2 Mine
Jessops Lode
MT. MASSON
Mount George Mine
MT. GEORGE
MARY RIVER
MAUDE CREEK
LUCY MINE

AUSTRALIA 1:63,360

BAN BAN
NORTHERN TERRITORY

PLATE 4

(BASED ON D52/80-6)

INDEX TO ADJOINING SHEETS

BATCHELOR	WOOL WONGA	MUNDOGIE HILL
BURNSIDE	BAN BAN	GOODPARLA NORTH
TIPPERARY	BURRUNDIE	GOODPARLA SOUTH

GEOPHYSICAL LEGEND

1250 / 1300 — *Magnetic contours with flight-line intersections*

Magnetic "low"

Boundary of 1965 detailed aeromagnetic survey

RECONNAISSANCE AEROMAGNETIC SURVEY, 1963

TOTAL MAGNETIC INTENSITY CONTOURS

MILES 1 0 1 2 3 4 5 6 7 8 MILES

KILOMETRES 1 0 1 2 3 4 5 6 7 8 9 10 11 12 KILOMETRES

MAGNETIC CONTOUR INTERVAL 10 GAMMAS

3°45'

True North

Mag North

TOPOGRAPHICAL LEGEND

River or creek

Road or track

Railway and siding

Homestead

Mine

Swamp

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.
To Accompany Record No. 1966/91

D52/B1-37