1967/35

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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1967/35

TENNANT CREEK DETAILED AEROMAGNETIC SURVEY,

NORTHERN TERRITORY 1966

by

W.A. FINNEY

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SUMMARY

From July to September 1966, a detailed aeromagnetic survey of five areas in the Tennant Creek mineral field was made by the Bureau of Mineral Resources. A total of 115 square miles was surveyed with the aims of assisting overall geological interpretation, and of locating areas of primary interest for further investigation by ground geophysical methods and ultimately by diamond drilling.

The detailed survey resolved several anomalies that had been detected in previous aeromagnetic surveys. Several anomalies are related to structural features and occur in areas favourable to economic mineralisation. Estimates of the depth and type of source rocks are made where possible.

A very disturbed magnetic contour pattern was detected in an area south-west of the North Star mine, and the source of the anomalies is interpreted as a fairly shallow and possibly flat-lying basic body. The eastern side of this region is a clearly defined magnetic lineament, and it is suggested that the lineament is fault-controlled.

1. INTRODUCTION

A detailed aeromagnetic survey of five areas in the Tennant Creek mineral field was flown by the Bureau of Mineral Resources (BMR) during the period early July to mid-September, 1966. The region surveyed, totalling 115 square miles, consists of three areas close to the Tennant Creek township and two areas approximately 30 miles to the north (Plate 1). A Cessna light aircraft VH-GEO was used with a proton precession magnetometer mounted in a towed bird. The line spacing was one-tenth of a mile and the altitude of the detector was maintained at approximately 250 ft above terrain (Appendix 1). Ground magnetic traverses were surveyed across some of the aeromagnetic anomalies to assist interpretation.

The survey area was proposed by the Geological Branch of the BMR in collaboration with the Northern Territory Administration. Area 3 and the south-western part of Area 6 enclosed magnetic anomalies on the D.C.3 aeromagnetic map which were thought to be associated with the intersection of mapped geological structures and magnetic lineaments. Area 6 was extended to the eastern side of the Stuart Highway in order to enclose the Edna Beryl and Whippet gold mines. Areas 1, 2, and 7 were of particular interest to the two main exploring companies in the area: Geopeko Ltd and Australian Development N.L., as both companies were actively exploring either within these areas or in the immediate vicinity.

The magnetic method of prospecting has been used with considerable success in the Tennant Creek area. Generally the method is used to locate non-outcropping ironstone bodies or extensions of outcrop, and is followed by drilling to test for mineralisation, which is mainly copper and gold, although bismuth has recently been found in economic quantities. Approximately one in every nine of the bodies located by this method is found to be mineralised. Other geophysical methods have been applied but with limited success in comparison to the magnetic method. In some cases the self-potential method has given reasonable results but attempts to use induced polarisation methods have not been encouraging. In recent years, the BMR has tried geochemical methods without much success.

The first magnetic surveys were made in 1935-37 by the Aerial, Geological and Geophysical Survey of North Australia (A.G.G.S.N.A.). A vertical-force variometer was used to survey a large grid combined with horizontal-force profiles over selected traverses. The results of the surveys were described by Daly (1957).

An airborne survey of part of the Tennant Creek field was made by the BMR in 1956 using a fluxgate magnetometer mounted in a D.C.3 aircraft. Lines were flown one-fifth of a mile apart at 500 ft above ground level. A large additional area was flown at a spacing of one-fifth of a mile in 1960 and the remainder of TENNANT CREEK was surveyed at 1-mile spacing in the same year. Extensive use of these results is made by geophysical exploration teams in the field. Private companies usually select specific aeromagnetic anomalies and make a more detailed ground magnetic survey in order to localise drilling targets.

Ground magnetic surveys have been made by the BMR Metalliferous Group (O'Connor, Goodchild, & Daly, 1962). In 1964, the BMR flew a detailed aeromagnetic survey over selected anomalies near the Peko mine and North Star mine (Milsom & Finney, 1965), coinciding with geochemical surveys in the same areas by the Geological Branch of the BMR (Dunnett, 1965; Harding, 1965).

2. GEOLOGY

The geology of the Tennant Creek mineral field has been the subject of a comprehensive study by Ivanac (1954), which includes all the known geology up to 1950. Further work is described by Crohn, Ryan, and Oldershaw (1959); Crohn (1963); Crohn and Oldershaw (1964); Dunnett (1965); Dunnett and Harding (1965); Harding (1965); and Yeamans (1965). Geological work has also been carried out by subsidiaries of Peko-Wallsend Investment Ltd and Australian Development N.L., but the results are not generally available.

Tennant Creek is considered by Ivanac to be a geosynclinal fold belt that has been stable since the close of the Lower Proterozoic apart from limited volcanic activity during the Middle Cambrian. The Warramunga Geosyncline developed early in the Proterozoic about an axis trending north-west. Orogenic movements followed and the Warramunga Group sediments were uplifted and intruded by granites. The sediments were probably affected by orogenic movements associated with the Davenport Geosyncline, which later developed to the south. These were the last major tectonic movements in the area and the present land surface results from the dissection of a Tertiary peneplain about 200 ft above the general present level.

Sedimentary

Archaean rocks are not known to crop out in TENNANT CREEK, but occur in a magnetically disturbed area (Area 3, Plate 1) twenty miles west-south-west of Tennant Creek, where they are overlain by up to 80 ft of unconsolidated grit and sandstone. Diamond-drill cores taken from this area reveal a complex of gneiss and amphibolite, containing magnetite-rich bands associated with granitic and gabbroic intrusions.

Most of the rocks cropping out in the Tennant Creek mineral field belong to the Lower Proterozoic Warramunga Group, which contains all the known mineral deposits. The group overlies ?Archaean gneisses and is overlain unconformably by the ?Middle Proterozoic Ashburton Sandstone, about four miles to the north of North Star.

The Warramunga Group consists of greywacke, tuffaceous greywacke, siltstone, and shale, with some grit and pebble beds. At the North Star mine pink and red siltstones are interbedded with the haematite shale and together constitute the main sedimentary rocks associated with the mineralisation. Poor outcrop and complex structures make a full understanding of the stratigraphy difficult.

Metamorphism of the Warramunga Group is found only at the margins of igneous intrusions and in the numerous shear zones, where chlorite, sericite, and talc have been reported. Two distinct classes of shears and faults have been recognised, the more widespread of which is characterised by north-westerly faults with associated north-easterly shears, and by quartz infillings which now give rise to prominent quartz ridges. The largest of these sheared fault zones extends from Quartz Hill to Rocky Range, dividing the Warramunga Group into two units. To the south and west of this zone the sediments are sharply folded and dips are generally steep and occasionally vertical, but to the north, folding is less intense and dips rarely exceed 45°. Smaller but more numerous shears post-date the quartz-filled type, differing from them in strike direction, some being infilled with ironstone (Crohn, 1963).

Upper Proterozoic and Lower Palaeozoic rocks crop out in the Tennant Creek mineral field but are known only in Area 7, where a fairly large outcrop of Rising Sun Conglomerate has been mapped. Only one of these younger formations, the Lower Cambrian Helen Springs Volcanics, is likely to be magnetic. In the greater part of the area to be surveyed bedrock is concealed by Recent alluvium and unconsolidated sediments.

Igneous

The Tennant Creek Granite Complex crops out extensively in the Tennant Creek mineral field. The Complex consists of at least four major phases, which are gneissic porphyritic, massive porphyritic, even-grained, medium-grained, and aplitic. The Complex is cut by quartz veins and dolerite dykes, and contains numerous small xenoliths and some infaulted wedges of sedimentary material.

The gabbro and dolerite are considered by Dunnett and Harding (1965) to be late intrusive rocks, either emplaced contemporaneously with, or post-dating, the mineralisation of the Warramunga Group, and may also be co-magmatic with the basic rocks of the Davenport Ranges and the Hatches Creek area. Other igneous rocks recorded from the Tennant Creek field comprise uralitised diorites from the Mary Lane and Golden Forty areas, a small occurrence of serpentine in the Caroline area, and a large number of lamprophyre plugs and dykes.

Contact metamorphism of the sediments is only slight, and in view of the presence of tuffs it is thought that igneous intrusions were near the surface.

3. MINERALISATION

Most of the known gold and copper mineralisation is associated with ironstone lodes. These ironstones are of a similar nature throughout the Tennant Creek field, being largely quartz-haematite bodies derived by oxidation of quartz-magnetite replacement bodies above the water-table. Throughtout most of the field, favourable beds (mudstone, shale, haematite shale) and favourable structures (shear zones, brecciation zones) have controlled mineralisation.

Gold is found in the ironstone or in the adjacent brecciated sediments and is invariably more plentiful in the oxidised zone owing to secondary enrichment. Very few gold deposits have been worked in the primary zone, where the gold is more finely divided and may be associated with sulphides.

Fewer copper deposits are known, and the Peko mine is the only major producer in the field. The Peko orebody, which has undergone secondary enrichment, resulted from the replacement of the interior of a magnetite pipe by massive sulphides. Structural control appears to have been exercised by two intersecting shear zones, one striking west, parallel to the strike of the sediments, and the other striking north-east. Other large copper deposits at Orlando and Ivanhoe mines are also located on major shear zones.

Dunnett and Harding (1965) are of the opinion that the mineralising hydrothermal solutions originated from the emplacement of gabbro and dolerite. They conclude that the ironstone bodies were derived from a basic rock source as opposed to the acid association suggested by Ivanac (1954) and Crohn and Oldershaw (1964).

4. RESULTS AND INTERPRETATION

The actual relation between copper, gold, and iron mineralisation is obscure, but places where the iron mineralisation is concentrated appear to be favourable locations for economic mineralisation also. Many of the concentrated 'ironstone bodies' give rise to magnetic anomalies of comparatively small areal extent and most of the main producing mines on the field appear to be associated with anomalies of this type. However, some large relatively isolated anomalies are associated with rocks which have a large haematite/magnetite content but little copper or gold mineralisation, for example at the Black Angel and Golden Forty prospects (Plate 1). Anomalies with large areal extent and general east-west elongation, which were recorded, for example, over Aeromagnetic Ridge, are generally attributed to disseminated magnetite within the Warramunga sediments, and are not considered to be associated with economic mineralisation.

Part of the interpretation of the survey data is aimed at distinguishing between anomalies thought to be due to disseminated magnetite and those due to ironstone bodies.

Area 7

This is a narrow rectangular-shaped area about 13 miles by 1.5 miles, with the major axis oriented approximately east-west. Nobles Nob and The Plum mines are situated near the westerly and easterly extremities respectively (Plate 2). This area is located on the southern flank of Aeromagnetic Ridge, a large part of which has already been covered by a detailed aeromagnetic survey (Milsom & Finney, 1965). The general pattern of the magnetic contours obtained in the present survey does not differ very much from that of the D.C.3 magnetic contours (Plate 1), but owing to the lower survey altitude and closer line spacing a few minor anomalies have been resolved.

Profiles were constructed from the magnetic contour map at AA', BB', etc. in order to carry out quantitative analyses. It is recognised that analytical treatment of the anomalies in many cases is not very reliable because most of the anomalies are complex; consequently calculated depths and dips of sources are only approximate.

An isolated anomaly occurs about 1½ miles west of the Red Terror mine, and the source of this is calculated to be about 250 ft below ground level (profile BB'). This anomaly appears to be due to a single source dipping fairly steeply, slightly north of west. Further ground investigation might be warranted but would be of low priority.

Approximately mid-way between the New Hope and Red Terror mines, about 0.5 miles north of the main track, an elongate anomaly runs about parallel to the extensive magnetic 'high' to the north. Analyses of profiles at a few places, e.g. FF' and GG' indicate a very shallow source, less than 100 ft in depth. The two individual peaks suggest concentrated sources and both are probably worth investigating. As the source is shallow this could be done relatively easily by hammer drilling.

About 0.7 miles south of this anomaly is a magnetic 'high' with a variable strike direction. A profile constructed across the main peak at DD' has been analysed and indicates a source at a depth of about 500 ft. This is probably due to an extension at depth of the ironstone that crops out to the north-east. Two such outcrops occur on the axis of the western end of the anomaly and it is possible that all three outcrops are connected at depth. The survey area did not extend far enough to the south to detect the minimum associated with this 'high', but from the available gradients on the southern flank of the anomaly it appears that the source at the western end dips steeply to the north, whereas at the main peak the source appears to dip fairly gently to the south. The source is deepest in the centre, rising to about 130 ft at the western end (CC') and about 250 ft at the eastern end (EE').

The New Hope mine is located on the flank of a small anomaly which is probably produced by a continuation at depth of the ironstone that crops out at the mine. The shape of the contours suggests that the ironstone body has a shallow plunge to the east and a steep dip to the north. The Plum mine is situated slightly to the west of the larger of two peaks of a small anomaly elongated northwest-southeast. Ground magnetic surveys would probably resolve these into separate anomalies, and calculations on the size and position of the causative bodies could be made from these. From the aeromagnetic results it appears that the centre of the sources are between 350 and 450 ft deep and the sources exhibit a steep northerly dip.

About half a mile north-west of New Hope mine there is a low-amplitude, fairly broad anomaly, the source of which appears to be distinct from the New Hope body. Depth estimates on profile HH' put the top of this source at a depth of approximately 350 ft. As both the Plum and New Hope mines have produced gold at shallow depths, further deeper testing of the anomalies in this area is recommended.

The anomaly with the largest amplitude occurs at the eastern extremity of the area. It has a general east-west trend and a strike length of about 1.5 miles. There are three individual peaks on this elongated 'high', the largest of which occurs about 1.3 miles north-east of The Plum mine and has an amplitude of 620 gammas from the peak to the minimum on the southern side (profile JJ'). The overall anomaly is very similar to those of Aeromagnetic Ridge and the source is probably disseminated magnetite within the Warramunga sediments at an estimated depth of 750 ft. However, the main peak might be due to the existence of a more concentrated source, possibly nearer the surface, and for this reason it is recommended that this anomaly be tested by drilling. Ground magnetic surveying should be able to distinguish a second source if it exists, and permit an estimation of its position.

Structural features are difficult to interpret as the area covered is comparatively small. The anomaly trends have been delineated together with positions where depth estimate calculations have been made. One interpreted fault has also been shown, extending in a general north-south direction between the New Hope and The Plum mines.

Area 1

This is a small rectangular area, about 5 miles by 1.5 miles with the major axis oriented W15° N (Plate 1). It is terminated on the eastern side by the Stuart Highway about 3 miles south of the Tennant Creek township. Plate 3 shows the magnetic contours and interpretation superimposed on the geology.

Two groups of small mines associated with ironstone outcrops occur at the eastern and western extremities of the area. Sediments of the Warramunga Group are the only other outcrops in the area. A 1400-gamma anomaly has been detected over one of the largest of these ironstone outcrops, Mount Samuel. The magnetic 'lows' associated with this anomaly suggest that the source is very shallow and of small depth extent. It is the only intense anomaly associated with any of the outcropping ironstone in the vicinity of Mount Samuel. The ironstone outcrops and small mines occur on the southern flank of a broad east-west 'high'. The magnetic character of this 'high' suggests that the source material is disseminated magnetite of variable concentration and magnetic susceptibility at depths ranging between 400 and 1000 ft.

The largest peak of the 'high' occurs 1.4 miles W25° N of Mount Samuel. An analysis of profiles (CC' and BB') constructed across this peak indicates a source with its upper surface at a depth of approximately 400 ft, if one assumes a tabular-type source with an approximate east-west strike. This is considered more applicable than a spherical-type source as used in Daly's method (Daly, 1957) which in this case gives results of about 1300 ft to the centre of a body with a radius of about 300 ft.

No localised anomalies were detected over the ironstone outcrops at the western end of the area, around the Skipper, Westward Ho, and Arcadia mines. A magnetic 'high' extends east from the region and develops into a more intense anomaly one mile east of the Arcadia mine. This is the only anomaly considered worth investigating further. A depth calculation on this anomaly (profile AA') puts the top of the source at a depth of between 400 and 500 ft.

Area 2

This is a rectangular area, 14 miles by 1.3 miles, with the major axis oriented approximately W15° N. It is located about 3 miles north of Tennant Creek and extends on both sides of the Stuart Highway (Plate 1).

The highest amplitude anomalies occur at the western end of the area (Plate 4). These have been extensively explored already and an economic orebody (Ivanhoe mine) is presently being worked there. These anomalies extend eastwards in a narrow tongue and develop another small peak, about 2.4 miles from the western boundary of the area. A profile constructed across the peak perpendicular to the magnetic strike at AA' indicates a source at about 300 ft below ground level, dipping to the south. Because it is located on the extension of an anomaly associated with a known orebody it is recommended that this anomaly be investigated further.

The main magnetic feature in the remainder of the area is an elongated magnetic 'high', which incorporates several individual anomalies, to the south of a major shear zone on which are located several small mines (Mascot, Mary Lane, Hidden Mystery, and Mary Ann). This region is a very favourable location for mineralisation and some of the anomalies are considered worth further investigation, particularly the two main anomalies located just to the south-east and south-west of the Mary Lane mine. These two anomalies are split by a negative magnetic trend which is a continuation of a pronounced magnetic lineament on the D.C.3 aeromagnetic map. This lineament possibly indicates a deep fault not easily recognisable on the surface.

Two diamond-drill holes, DDH1 and DDH2, have been completed on the anomaly to the south-east of the Mary Lane mine but they showed only small traces of gold and copper mineralisation. Several intersections of lamprophyre were detected and it is possible that this might be the source of the anomalies. However, these holes were sited on the basis of geochemical information and it is possible that a ground magnetic survey might indicate different targets which might warrant further investigation. A profile across the main anomaly at BB' indicates a source at a depth of about 150 ft. The profile is complex and it is possible that there is a second source at greater depth. This is partly borne out by calculations on the profile at CC', which puts the source at a depth of approximately 950 ft.

The anomaly about 0.2 miles east of the highway has been analysed (profiles DD' and EE') and indicates a source at a depth of approximately 400 ft. The magnetic 'high' extending to the Mary Ann mine is due to a source at a similar depth. East of this mine the source appears to deepen but insufficient data are available to make a reasonable estimate of its depth.

Area 3

This is a small area, approximately 4 miles by 2 miles, located about 3 miles north-west of the Orlando mine (Plate 1). It was chosen to delineate more clearly an anomaly on the D.C.3 aeromagnetic map that lies at the intersection of a north-west magnetic lineament and the extension of a north-east shear zone, the Northern Star Shear Zone (Dunnett & Harding, 1965). The detailed survey resolved the D.C.3 magnetic pattern into a broad north-west magnetic 'high', which develops a narrow elongated peak extending one mile in from the northern boundary of the area (Plate 5).

The magnetic field in the area increases from south to north and from east to west. The D.C.3 contours indicate that these gradients continue for several miles and a large anomaly with a broad peak is developed about 8 miles W20°N of Area 3. The overall dimensions of this anomaly suggest a possible basic source at depth. The minor anomaly in Area 3 is possibly related to this deep source, although it is due to a body much closer to the surface. Calculations based on the profiles (AA', BB', and CC') constructed across the magnetic strike put the source at depths ranging between 100 and 200 ft, it being deeper at the northern end. The body is probably tabular in shape and dips steeply to the north-east.

No outcrop occurs in the area occupied by the main 'high' but Warramunga sediments and several small porphyry outcrops occur about 0.5 miles to the south. Another possibility, therefore, is that the source of the anomaly is related to the prophyry. As the porphyry might be the source rock for the gold and copper mineralisation, the anomaly is worth further investigation.

The two main peaks of the anomaly lie approximately on the extension of two mapped faults, the strike of which follows the general strike of the anomaly. Consequently, structural control of the source material is suggested.

Area 6

This area, of 61 square miles, extends east and west of the Stuart Highway about 24 miles north of the Tennant Creek township (Plate 1). A small portion around the North Star mine was not included as it has been surveyed previously (Milsom & Finney, 1965).

The contour pattern as detected in the detailed survey falls into two fairly distinct zones (Plate 6). One is the highly disturbed region located in the south-west corner of the area, within which are many small anomalies with amplitudes of about 200 gammas. The other zone, which includes the remainder of the area, is relatively undisturbed; magnetic gradients are small and there is only one anomaly with amplitude greater than 200 gammas. The boundary between the two zones is abrupt and is indicated by a steep magnetic gradient striking N20° E, at longitude 134°04' approximately. There is no surface geological expression of these two zones. The most disturbed area is soil covered, and the few outcrops that do exist seem to be non-magnetic.

Several anomalies in the magnetically disturbed zone have been analysed and depths to source range from near-surface to approximately 700 ft. It is difficult to choose a model on which to base analytical calculations because of the irregular shape of anomalies, but the overall contour pattern suggests sources of limited depth extent. These could be produced by local variations in magnetic susceptibility within a single source rock such as a flat-lying basic igneous body. The abrupt boundary between the two zones suggests that the source rock is terminated on the eastern side by a fault. However, there is little geological evidence of faulting in this direction.

A programme of drilling to bedrock to obtain geological information across the boundary of the two zones is recommended. An exploratory diamond-drill hole is tentatively proposed to investigate one of the higher amplitude anomalies such as those analysed along DD', EE', or FF'.

In the eastern zone, the only intense anomaly occurs near the southern boundary about 1.5 miles east of the Stuart Highway. This anomaly is approximately 200 gammas in amplitude and has been analysed along sections AA' and BB'. The source body appears to dip at a shallow angle to the south and is about 300 ft deep near the peak of the anomaly. A second small magnetic 'high' analysed along CC' indicates a source at a depth of about 800 ft.

There is no magnetic evidence of the Northern Star Shear, which passes south of the North Star mine (Dunnett & Harding, 1965). No magnetic anomalies are associated with either the Edna Beryl or Whippet mines.

5. CONCLUSIONS AND RECOMMENDATIONS

The detailed aeromagnetic survey was successful in delineating, in the five areas surveyed, several magnetic features that are not apparent on the D.C.3 regional contour map (Plate 1). In Areas 1, 2, 3, and 7 anomalies are more clearly defined, and in the south-west corner of Area 6 a magnetically disturbed zone has been observed which is terminated on the eastern side by a distinct magnetic lineament.

As outlined in Chapter 4, it is recommended that five anomalies in Area 7, one in Area 1, three in Area 2 and one in Area 3 should be investigated further by ground magnetic surveys and tested for mineralisation by either hammer or diamond drilling. Shallow drilling (possibly hammer drilling) is specifically recommended to obtain geological information across the magnetic lineament in Area 6. Two, or possibly three, anomalies in the disturbed zone of this area, should be tested by diamond drilling.

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APPENDIX 1

Operational details

Survey specifications

Detector altitude	:	250 ft above ground level
Line spacing	:	one-tenth of a mile
Line orientation	:	approximately east-west in areas 1, 3, 6, and 7; northwest-southeast in area 2
Area surveyed	:	115 square miles

Equipment

Aircraft	:	Cessna 180
Magnetometer	:	MNS1 proton procession type of BMR design
Recorders	:	One Mosley Autograf, sensitivity 100 gammas F.S.D.
		One Mosley Autograf, sensitivity 10,000 gammas F.S.D.
Camera	:	Modified Vinten, single-frame type 35-mm with 186° fish-eye lens
Radio altimeter	:	AN/APN - 1
Storm warning detector	:	MFD3 - fluxgate type of BMR design, sensitivity approximately 300 gammas F.S.D.
Ground magnetometer	:	A.B.E.M. vertical-force type

Method

A correction for diurnal variation was determined by flying a pre-selected baseline at the beginning and end of each flight. 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. A ground fluxgate magnetometer served as a magnetic storm warning device.

The output of the magnetometer had a noise envelope of approximately 10 gammas, and a physical smoothing of the profile was done before the magnetic values were transferred to construct the contour map.

The actual flight path of the aircraft was recorded on film, which was later correlated to aerial photographs and thence to photoscale planimetric base maps. The maximum probable positional error is estimated to be ± 150 ft.

Personnel

The personnel engaged on the survey were:

BMR - W. A. Finney, E. P. Shelley, W. R. D. Buckley, B. Tregellas, G. Sauerberg

T.A.A.- First Officer J. Lord

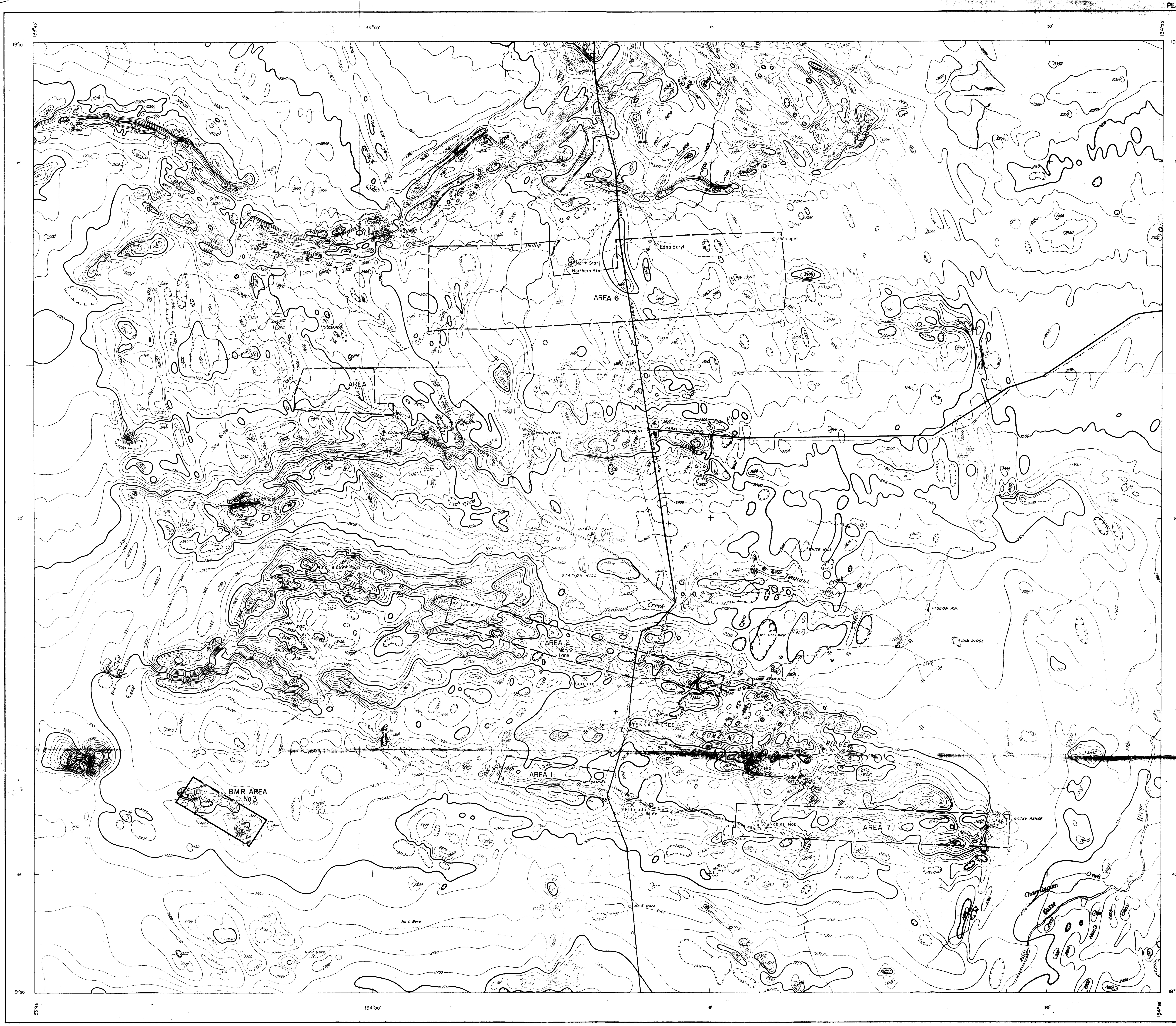
APPENDIX 2

Interpretation methods

The interpretation methods employed can be grouped into qualitative and quantitative analyses.

Qualitative interpretation involved the determination of the strike of magnetic bodies by delineating the trends of the magnetic 'highs' and 'lows' and noting abrupt displacements of trend lines which were considered indicative of faulting. The position of the magnetic 'lows' relative to the magnetic 'highs' was sometimes used as an indication of the dip of the magnetic body and its depth extent.

Quantitative interpretation mainly involved the determination of the depths to the tops of the magnetic bodies, but the dips and magnetic susceptibilities were also calculated if the anomaly profiles were suitable. The methods used were the half-maximum-slope method of Peters (1949), the three methods of Moo (1965) and the maximum-minimum method of Daly (1957). The methods of Peters and Moo assume the magnetic body is tabular in shape and has only one finite dimension; Daly's method is based on the assumption of a spherical body; all of them assume the magnetisation is wholly induced. The choice of the method used was determined by inspection of the contour map, noting the strike of the anomaly and the position of associated 'lows'.



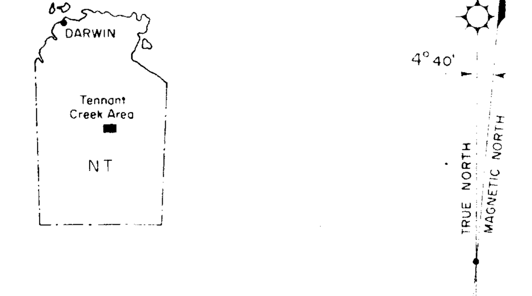
DETAILED AEROMAGNETIC SURVEY, TENNANT CREEK NT, 1966.

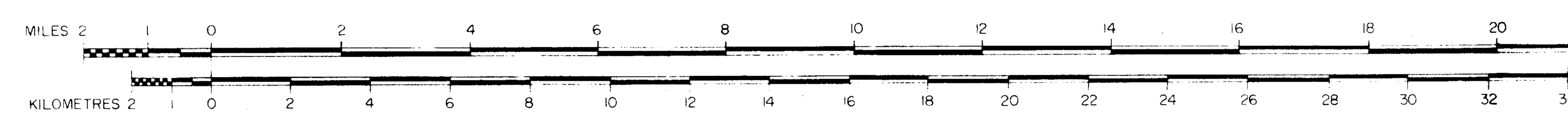
LOCALITY MAP

AND

DC. 3 TOTAL MAGNETIC INTENSITY CONTOURS

LOCATION DIAGRAM





MAGNETIC CONTOUR INTERVAL 50 GAMMAS

TOPOGRAPHICAL LEGEND

- River or creek
- Highway or main road
- Secondary road
- Road or track
- Bore
- Mine
- Aerodrome or landing ground
- Hill feature
- Boundary of survey area

GEOPHYSICAL LEGEND

- Magnetic contour (2750, 2500)
- Magnetic 'low'

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

E53/B1-19-1

TO ACCOMPANY RECORD No 1967/35

AREA 7
TOTAL MAGNETIC INTENSITY CONTOURS, GEOPHYSICAL INTERPRETATION AND GEOLOGY

BASED ON E53/B0-37, E53/B0-42, E53/B1-45

MILES

KILOMETRES

MAGNETIC CONTOUR INTERVAL 10 GAMMAS

GEOLOGICAL LEGEND

CAINOZOIC
- Cz — Gravel, sand, silt, clay

PRECAMBRIAN

PROTEROZOIC UPPER

RISING SUN CONGLOMERATE
- Conglomerate, quartzite sandstone, shale

UPPER AND LOWER
- Quartz
- Lamprophyre

LOWER
- Quartz haematite - magnetite (ironstone)
- Haematite jasper
- Quartz - feldspar porphyry
- Quartz - baveno feldspar porphyry
- di — Diorite
- s — Serpentine
- Quartz - feldspar porphyry
- Pg — Granite

WARRAMUNGA GROUP
- Plw₁ — Shale, some greywacke
- Greywacke, shale
- Plw₃ — Sandstone, shale, siltstone

- Quartz - filled fault
- Fault
- Anticline
- Syncline
- Trend of bedding
- Shear zone
- Geological boundary

4°40' TRUE NORTH MAGNETIC NORTH

TOPOGRAPHICAL LEGEND
- River or creek
- Highway
- Road or track
- Mine

GEOPHYSICAL LEGEND
- 700 750 Magnetic contours
- Magnetic 'low'
- Positive magnetic trend
- Negative magnetic trend
- Interpreted fault
- A — A' Section where magnetic profile was constructed from contours
- A — A' Section and position of calculated depth value

THE MAGNETIC DATA HAVE NOT BEEN CORRECTED FOR THE REGIONAL MAGNETIC GRADIENT

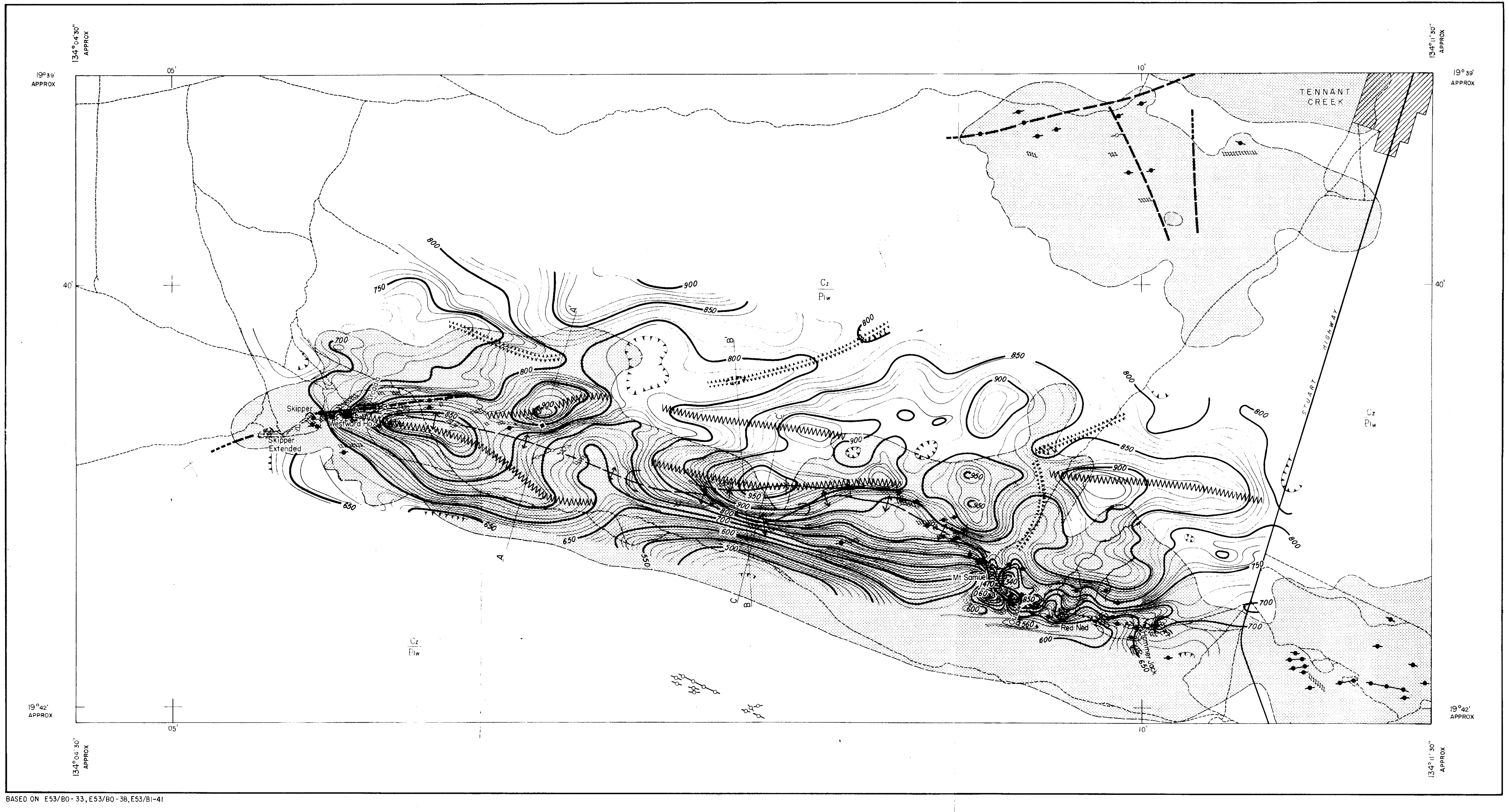
GEOLOGY AFTER P.W. CROHN AND W. OLDERSHAW, 1964

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics E53/B1-40
TO ACCOMPANY RECORD No. 1967/35

PLATE 3

AREA I

TOTAL MAGNETIC INTENSITY CONTOURS, GEOPHYSICAL INTERPRETATION AND GEOLOGY



MILES 1 0 1 2

KILOMETRES 1 0 1 2 3

MAGNETIC CONTOUR INTERVAL 10 GAMMAS

GEOLOGICAL LEGEND

CAINOZOIC

- Cz — Gravel, sand, silt, clay

PRECAMBRIAN

PROTEROZOIC
UPPER
RISING SUN CONGLOMERATE

- Conglomerate, quartzite sandstone, shale

UPPER AND LOWER

- Quartz
- Lamprophyre

LOWER

- Quartz haematite - magnetite (ironstone)
- Haematite jasper
- Quartz feldspar porphyry
- Quartz - baveno feldspar porphyry
- Diorite
- Serpentine
- Quartz feldspar porphyry
- Granite

WARRAMUNGA GROUP

- Plw₁ — Shale, some greywacke
- Greywacke, shale
- Plw₃ — Sandstone, shale, siltstone

- Haematite-filled fault
- Fault
- Anticline showing plunge
- Syncline
- Trend of bedding
- Shear zone
- Geological boundary

TRUE NORTH
MAGNETIC NORTH
4°4'

TOPOGRAPHICAL LEGEND

- River or creek
- Highway
- Road or track
- Mine

GEOPHYSICAL LEGEND

- 700 / 750 — Magnetic contours
- Magnetic 'low'
- Positive magnetic trend
- Negative magnetic trend
- A A' — Section where magnetic profile was constructed from contours
- A A' — Section and position of calculated depth value

THE MAGNETIC DATA HAVE NOT BEEN CORRECTED FOR THE REGIONAL MAGNETIC GRADIENT

GEOLOGY AFTER P.W. CROHN AND W. OLDERSHAW, 1964

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics E53/B1-36
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AREA 2
TOTAL MAGNETIC INTENSITY CONTOURS, GEOPHYSICAL INTERPRETATION AND GEOLOGY

MILES 1 0 1 2

KILOMETRES 1 0 1 2 3

MAGNETIC CONTOUR INTERVAL 10 GAMMAS

GEOLOGICAL LEGEND

CAINOZOIC
- Gravel, sand, silt, clay

PRECAMBRIAN

PROTEROZOIC

UPPER

RISING SUN CONGLOMERATE
- Conglomerate, quartzite sandstone, shale

UPPER AND LOWER
- Quartz
- Lamprophyre

LOWER
- Quartz – haematite – magnetite (ironstone)
- Haematite – jasper
- Quartz - feldspar porphyry
- Quartz - baveno feldspar porphyry
- di Diorite
- s Serpentine
- Quartz - feldspar porphyry
- Pg Granite

WARRAMUNGA GROUP
- Plw Shale, some greywacke
- Greywacke, shale
- Plw3 Sandstone, shale, siltstone

- Quartz - filled fault
- Fault
- Anticline showing plunge
- Syncline
- Trend of bedding
- Shear zone
- Geological boundary

4°40' MAGNETIC NORTH TRUE NORTH

TOPOGRAPHICAL LEGEND

- River or creek
- Highway
- Road or track
- Mine
- DDH Diamond drill hole

GEOPHYSICAL LEGEND

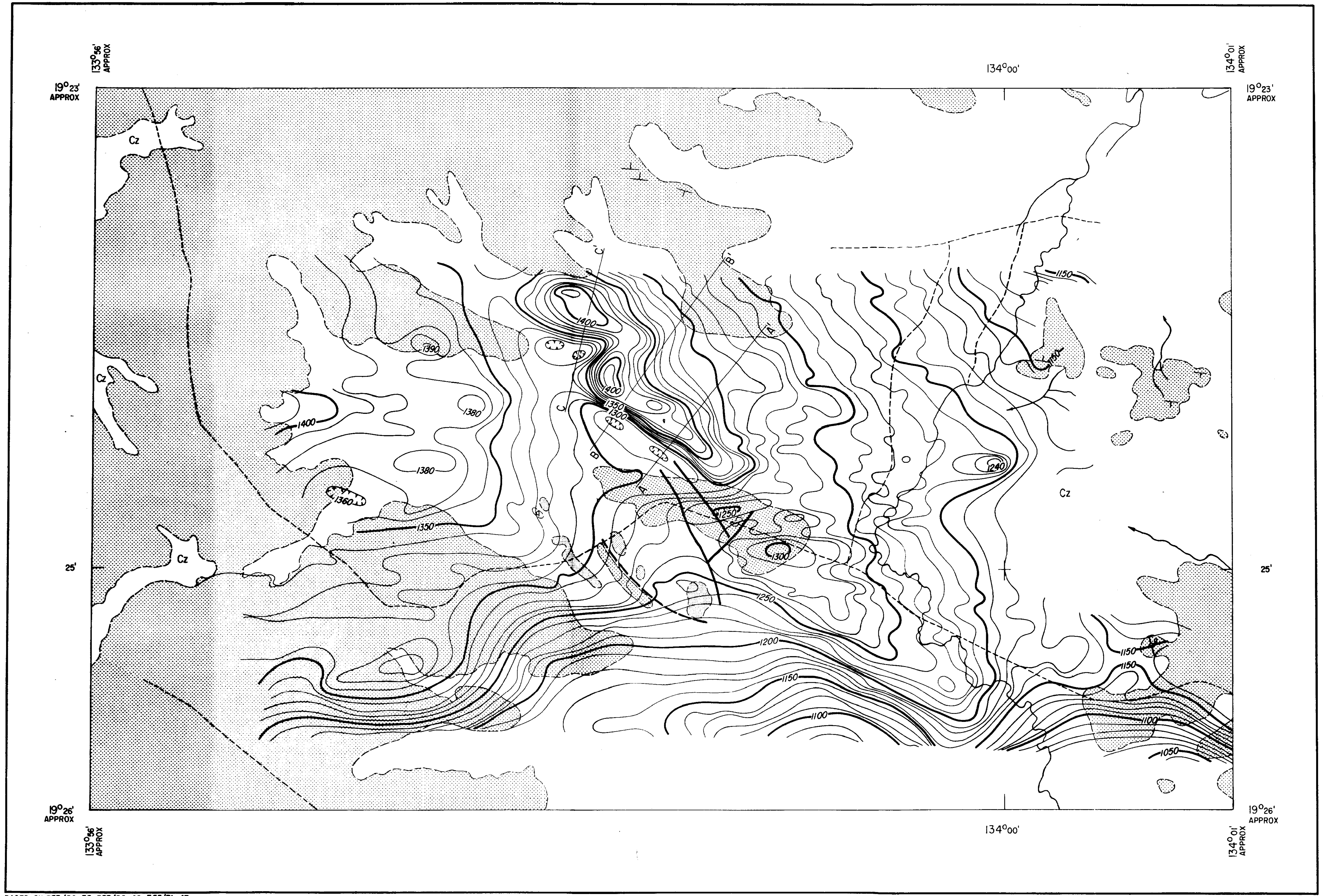
- 700 750 Magnetic contours
- Magnetic 'low'
- Positive magnetic trend
- Negative magnetic trend
- A A' Section where magnetic profile was constructed from contours

THE MAGNETIC DATA HAVE NOT BEEN CORRECTED FOR THE REGIONAL MAGNETIC GRADIENT

GEOLOGY AFTER P.W.CROHN AND W. OLDERSHAW, 1964

BASED ON E53/B0-34, E53/B0-39, E53/B1-42

Bureau of Mineral Resources, Geology and Geophysics E53/B1-37
TO ACCOMPANY RECORD No. 1967/35



BASED ON E53/B0-35, E53/B0-40, E53/BI-43

AREA 3

TOTAL MAGNETIC INTENSITY CONTOURS, GEOPHYSICAL INTERPRETATION AND GEOLOGY

MILES 1 0 1 2 MILES

KILOMETRES 1 0 1 2 3 KILOMETRES

MAGNETIC CONTOUR INTERVAL 10 GAMMAS

GEOLOGICAL LEGEND

CAINOZOIC

Cz — Gravel, sand, silt, clay

PRECAMBRIAN

q — Quartz vein, quartz

Porphyry

Greywacke, shale, sandstone, siltstone

Geological boundary

Fault

Dip and strike of strata

TRUE NORTH

MAGNETIC NORTH

4°40'

TOPOGRAPHICAL LEGEND

River or creek

Road or track

GEOPHYSICAL LEGEND

700 750 Magnetic contours

Magnetic 'low'

A A' Section where magnetic profile was constructed from contours

GEOLOGY FROM GEOPEKO LTD
AERIAL PHOTOGRAPH

THE MAGNETIC DATA HAVE NOT BEEN CORRECTED FOR THE REGIONAL MAGNETIC GRADIENT

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TO ACCOMPANY RECORD No. 1967/35

AREA 6

TOTAL MAGNETIC INTENSITY CONTOURS, GEOPHYSICAL INTERPRETATION AND GEOLOGY

GEOLOGICAL LEGEND

CAINOZOIC
- Cz — Sand, gravel, alluvium silt, "bulldust"

PALAEOZOIC
- CAMBRIAN
- GUM RIDGE FORMATION AND HELEN SPRINGS VOLCANICS
  - Lava, pyroclasts, shale calcareous sandstone, chert

PRECAMBRIAN
- LOWER PROTEROZOIC
  - Quartz - haematite - magnetite - jasper (ironstone)
  - Quartz
- TENNANT CREEK GRANITE COMPLEX
  - Quartz feldspar porphyry
  - Pg — Porphyritic, coarse, fine, even-grained granite
- WARRAMUNGA GROUP
  - Pws — Shale, siltstone, haematite shale, volcanics
  - Pwg — Quartz, greywacke, quartz sandstone minor shale, volcanics
  - Pwb — Acid volcanic flows, ashstone, volcanic greywacke
  - Shale lenses, minor siltstone
  - Pww — Quartz sandstone, quartz pebble conglomerate
  - Pw — Undifferentiated: greywacke, shale, siltstone, volcanics etc.

- Fault
- Shear zone
- Lineament
- Geological boundary

4°40'
TRUE NORTH
MAGNETIC NORTH

TOPOGRAPHICAL LEGEND

- River or creek
- Highway
- Road or track
- Mine

GEOPHYSICAL LEGEND

- 700 / 750 — Magnetic contours
- Magnetic 'low'
- Positive magnetic trend
- Negative magnetic trend
- Interpreted fault
- A — A' Section where magnetic profile was constructed from contours
- A — A' Section and position of calculated depth value

GEOLOGY AFTER D.DUNNET AND R.R.HARDING, 1965

THE MAGNETIC DATA HAVE NOT BEEN CORRECTED FOR THE REGIONAL MAGNETIC GRADIENT

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics E53/B1-39
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