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RECORD No. 1964/180

TENNANT CREEK DETAILED AEROMAGNETIC SURVEY, NT 1964

by

J.S. Milsom and W.A. Finney

RESTRICTED

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DETAILED AEROMAGNETIC SURVEY

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SUMMARY

In September 1964 a detailed aeromagnetic survey of three areas in the Tennant Creek Mineral Field was carried out by the Bureau of Mineral Resources. The three areas, Aeromagnetic Ridge, North Star and Gigantic (Plate 1) had been selected by the Geological Branch of the Bureau as being of particular interest to them. A geochemical party from the Geological Branch was working in the first two areas during May-September 1964.

The detailed aeromagnetic survey delineated several anomalies on and close to Aeromagnetic Ridge. Investigations into these have shown that only two of them appear to be associated with high copper concentrations which might warrant further investigation, and estimates of the depth and type of source rock have been made. Outside the geochemical grid area (Plate 3) the interpretation has been more difficult, but several other interesting anomalies have been noted and a limited interpretation has been attempted. The effect on the contour pattern by the Peko Shear has also been observed.

Large isolated anomalies were found in the North Star area and Gigantic area. A possible structural similarity between the two areas, as shown by the contour patterns obtained, has been noted. Estimates of depth to source rock have been made in each case.

I. INTRODUCTION.

A detailed aeromagnetic survey of three areas in the Tennant Creek Mineral Field was flown by the Bureau of Mineral Resources in September 1964. The three areas, Aeromagnetic Ridge, North Star and Gigantic were proposed by the Geological Branch of the Bureau in collaboration with the Northern Territory Administration.

All of the Tennant Creek 1:250,000 area had already been surveyed by the aeromagnetic method; Bureau of Mineral Resources, Geophysical Map G110-30 (1956) and Spence, (1963). A considerable amount of ground magnetic surveying had taken place around Tennant Creek. Surveys carried out prior to the second world war by A.G.G.S.N.A. are reported in a Bureau bulletin, Daly, (1957), and recent surveys by the Bureau of Mineral Resources, Daly (1959), Douglas (1962), (1964a), (1964b), O'Connor and Daly (1958), (1962), O'Connor, Goodchild and Daly (1959), and by private companies have covered many of the most interesting anomalies.

On the basis of the results of these surveys together with geological information a gridded area (Plate 3) on Aeromagnetic Ridge and an area around North Star were selected by the Geological Branch for a geochemical survey from May to September, 1964.

Two of the areas flown in the present detailed aeromagnetic survey were selected with the specific aim of facilitating interpretation of the geochemical results. It was hoped that the aeromagnetic survey would detect features which may have a bearing on the gold and copper mineralisation. Gold mineralisation at Tennant Creek has been found, with few exceptions, to be associated with ironstone bodies which are often magnetic. Fewer copper ore bodies are known and no satisfactory theory of mineralisation for them has been developed but it appears that shear zones are a major controlling factor. Consequently an attempt was being made not only to delineate anomalies more precisely but also to locate the Peko Shear and in general obtain more information about the structure of both areas.

The main purpose in the Gigantic area was to resolve and obtain further information about the anomaly shown to exist by the ~~1960~~ 1956 D.C.3 survey with a view to detecting the continuation of the Peko Shear.

2. GEOLOGY

The geology of the Tennant Creek Mineral Field has been described by Ivanac (1954), whose report includes all the known geology to 1950, and by Crohn, Ryan and Oldershaw (1959), by Crohn (1963) and by Crohn and Oldershaw (1964). Considerable geological work has also been carried out by Peko-Wallsend Investments Ltd. and by Australian Development N.L. but the results are not generally available.

Tennant Creek lies in a geosynclinal fold belt which has been stable since the close of the Lower Proterozoic, apart from limited volcanic activity during the Middle Cambrian. The Warramunga Geosyncline developed very early in the Proterozoic about a north-west trending axis passing to the south of the site of Tennant Creek township, and a thick sedimentary sequence was laid down. Orogenic movements succeeded the geosynclinal phase and the Warramunga Group sediments were uplifted, deformed and intruded by granites. The sediments were probably also affected by orogenic movements associated with the Davenport Geosyncline which later developed to the south-east. These were the last major tectonic movements in the area, the present land surface resulting from the dissection of a Tertiary peneplain some 200 ft. above the general present-day level.

Stratigraphy

Sedimentary. Archaean rocks do not crop out in the Tennant Creek 1:250,000 area, but are thought to exist in a magnetically disturbed area (B.M.R. Area No. (Plate 1) twenty miles west-southwest of Tennant Creek where they are overlain by up to 80 ft of unconsolidated grits and sandstones. Diamond drill cores taken from this area consist of a complex of gneisses and amphibolites, containing magnetite-rich bands and associated with granitic and gabbroic intrusions. The observed magnetic anomalies are caused by this magnetite and are not associated with mineralisation.

Most of the rocks cropping out in the Tennant Creek area belong to the Lower Proterozoic Warramunga Group, which contains all the known mineral deposits. The group consists of greywacke, tuffaceous greywacke, siltstone and shale with some grits and pebble beds. Classification and subdivision

has been hindered by the poorness of outcrop as well as the lack of marker beds and the great complexity of structures. Near Mt. Cleland a section of about 2,500 ft. of shales and siltstone, overlain by a rather greater thickness of shales and greywacke, can be traced. A band of hematite shale within the greywacke shale has been used as a marker bed and is often associated with ironstone lodes.

Metamorphism of the Warramunga group is intense only at the margins of the igneous intrusions and in the numerous shear zones, where chlorite, sericite and talc have been formed. Two distinct classes of shears and faults have been recognised, the more widespread of which is characterised by a main north-westerly trend with associated north-easterly shears, and by quartz infillings which now give rise to prominent quartz ridges. The largest of these shears extends from Quartz Hill to Rocky Range, dividing the Warramunga Group into two units. To the south and west of the shear the sediments are sharply folded and dips are generally steep and occasionally vertical, but to the north folding is less intense, with dips rarely exceeding 45°. Smaller but more numerous shears post-date the quartz filled type, differing from them in strike direction and in being infilled with ironstone. These lodes are more fully discussed in the section on mineralisation.

In the north of the Mt. Woodcock 1:63,660 area, the Warramunga Group is overlain, probably unconformably, by the Ashburton Sandstone. Although rocks of this group crop out strongly just north of the North Star survey area, they are not thought to exist within it.

Upper Proterozoic and Lower Palaeozoic rocks crop out in both the Mt. Woodcock and Tennant Creek 1:63,660 areas, but are not known in any of the parts covered by the detailed aeromagnetic survey. Only one of these younger formations, the Middle Cambrian Helen Springs Volcanics, is likely to be active magnetically. In most of the surveyed areas the bedrock is concealed by Recent alluvium and unconsolidated sediments.

Igneous. The Warramunga Group has been intruded by a possibly co-magmatic series of acidic igneous rocks ranging from massive foliated granites and adamellite through quartz feldspar and granite porphyry plugs

and dykes to volcanic pipes of welded tuff. The relatively slight contact metamorphism of the sediments and the presence of the tuffs (ignimbrites) are suggestive of a near surface intrusion. Large granitic complexes crop out a few miles to the north and south of Tennant Creek township, but the porphyries, scattered through the field and elongated parallel to the west striking sediments, usually extend over a few square miles only.

Basic igneous rocks occur in a few places and are thought to be related to the known mineralisation by some of the geologists working in the area. However some at least of the basic rocks post date mineralisation. Lamprophyre dykes, possibly deriving from a basic stock crop out in many parts of the field, and are seen to intersect both the ironstones and the Upper Proterozoic Rising Sun Formation.

Mineralisation

With the exception of two auriferous quartz veins entirely within porphyry, the known gold mineralisation at Tennant Creek is associated with the ironstone lodes. Below the water table the lodes are quartz-magnetite bodies, but near the surface the magnetite has been altered to hematite and any sulphides formerly present have been leached out.

The majority of the economically important ironstones are found close to the hematite shale marker bed. Ironstones may partially replace the shale, but more commonly occur where shear zones intersect it. An important feature is the repetition of ore shoots, which may occur down dip or down pitch from an outcropping quartz hematite lens. Gold is found in the ironstone or in the adjacent brecciated sediments, and is invariably more plentiful in the oxidised zone, due to secondary enrichment. It is probable that most of the gold in the sediments derived from the ironstones and was transported during erosion. 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 considerable producer in the field. The Peko ore body, 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, striking west, parallel to the strike of the sediments, and north-east. The north-east shear is a prominent photolinear feature which can be traced south to the region of granite outcrop and north at least as far as the Gigantic Mine. Other important copper deposits also appear to be located at the intersection of major shear zones.

Recent mineragraphic investigations at Peko have indicated that emplacement of the ironstone was essentially complete before the gold and sulphides were introduced (Edwards 1955). If the two, or possibly three, phases of mineralisation were distinct there is no reason to suppose that gold and sulphide deposits are necessarily associated with the ironstones. The observed relationships may merely be the result of much of the emplacement being controlled by the same solution channels. The softer shear zones, having eroded more readily than the ironstones, have been less intensively prospected to date.

3. INTERPRETATION

The interpretation of the results of the detailed aeromagnetic survey is considerably assisted if the earlier D.C.3 aeromagnetic contour map and the recent geochemical work in the area are considered. These surveys are therefore briefly described below.

The detailed survey of the central part of the Tennant Creek 1:250,000 area made with the Bureau's D.C.3 aircraft in 1956 recorded aeromagnetic and radiometric data (Map No. G110-30). The aircraft was flown at a nominal height of 500 ft. above ground level along Shoran controlled arcs at intervals of about 1/5 of a mile. In the Peko area the arcs were such that the aircraft was heading approximately north or south. A contour interval of 50 gammas was used for the final map (Plate 1).

The geochemical survey took place in May-September 1964, and covered an area 4,000 ft. by 30,000 ft. in the alluviated flat north of Peko (Plate 3), where the D.C.3 survey had shown a broad, east-west elongated

magnetic high, ~~sometimes~~ known as the 'aeromagnetic ridge'. Samples of weathered rock from below the iron enriched or silicified upper levels were taken by auger drilling. The depth of the drill holes varied between 6 ft. and 52 ft., but averaged about 22 ft. The holes were sited on near north-south lines 400 ft. apart, and were spaced down these lines at intervals of one hundred or two hundred feet. Samples were analysed by [redacted] spectrograph for content of copper, lead, zinc, nickel, cobalt and bismuth. In two places where anomalously high copper concentrations were noted further drilling was carried out, including several holes to a depth of about 100 ft. Results are probably not sufficiently encouraging to warrant further work in the area. Additional drilling and surface geochemical sampling was carried out in the North Star area, 25 miles north of Tennant Creek. The Mt. Woodcock 1:63,360 area was mapped geologically in conjunction with this programme.

The three areas for detailed aeromagnetic survey were selected after consultation with the Geological Branch. First and second priorities were allotted to areas north of Peko and at North Star which included the geochemical grids. Aeromagnetic results in parts of these areas can be directly related to recent geological and geochemical surveys. The third priority area includes the Gigantic Mine, where the D.C.3 survey detected a very localised but intense magnetic anomaly. The mine lies at the north-east end of the Peko shear zone, and it was hoped that some information about this shear could be obtained.

Interpretation of ground magnetic results in the Tennant Creek area has been based on methods described by Daly, using a spherical model of the source (Daly 1957). The method used in the present report assumes a source of infinite vertical extent, i.e. a pipe or dyke type of body. Sources are estimated by this method to be rather shallower and further north than they would be if the spherical model were used. Major anomalies detected by airborne methods usually derive from sources of considerable vertical extent, and results based on the dyke model have been found to be reasonably satisfactory in most mineral fields.

'Aeromagnetic Ridge' Area

The dominating feature of the aeromagnetic contours to the east of

Tennant Creek township is the east-west elongated high known as the 'aeromagnetic ridge'. This 'ridge' is even more pronounced on the detailed map than on the earlier D.C.3 contours. It extends west of the survey boundary near Tennant Creek to an abrupt termination north-east of the Golden Forty anomaly. The western end of the 'ridge' is much less sharply defined, the amplitude falling off westwards from about three miles east of Tennant Creek. On the D.C.3 magnetic map there is a strong north-easterly lineation, the Golden Forty lineation, running close to both Nobles Nob and Golden Forty, the magnetic pattern east of the lineation having apparently been shifted south about one mile. The Peko shear zone, which is a photo interpreted feature, runs through the Gigantic and Peko mines parallel to the Golden Forty lineation and appears to have shifted the magnetic pattern in a similar sense but to a less marked degree. Whereas the Peko shear zone only disrupts the 'ridge anomaly' the Golden Forty lineation terminates it. There is little or no evidence of lateral movement in the Warramunga sediments along the Golden Forty lineation but there is a definite quartz filled zone. This suggests that the movement is mainly a basement feature, but that there was some activity in the zone after deposition of the Warramunga sediments.

Three main types of magnetic source rock are known in the Tennant Creek Mineral Field. These are the ironstones, basic igneous rocks, and Pre-Warramunga schists and gneisses. Small magnetic anomalies may also derive from porphyries.

The ironstone (quartz-hematite-magnetite) bodies, which are associated with most of the known economic mineralisation, have been intensively prospected by the magnetic method. Although lodes of this type may be the source of some of the smaller anomalies along the 'ridge', it seems unlikely that they alone could produce such an extensive and continuous feature. In the north-west part of the 'aeromagnetic ridge' area a line of magnetic anomalies striking approximately west-north-west from the 'ridge' is attributed to ironstones, as are a few other anomalies that will be noted later. However, most of the magnetic highs occurring along the 'ridge' are more likely to be due to segregations of magnetic material within the source rocks, or to an uneven topography of the upper surface of the source.

Basic igneous rocks are possible magnetic sources in the Tennant Creek field. Very few are known at present, but there are some grounds for supposing that they are more widespread than appears from surface mapping. Some theories of the mineralisation postulate basic sources for the mineralising solutions. Also lamprophyre dykes are present in various parts of the field, including at least one in the area of the geochemical grid, and these may derive from a more basic stock at depth. In this connection it is worth noting the close proximity of the 'ridge' to many of the known ironstones, and to the very large magnetic anomalies at Peko and Golden Forty.

As noted earlier, a diamond drill hole put down in the B.M.R. No. 3 area intersected magnetite rich schists, gneisses and gabbro. These rocks could not be correlated with any part of the almost unmetamorphosed Warramunga sequence and are tentatively considered to be Archaean. It is possible that the 'aeromagnetic ridge' is caused by a block of similar material faulted into the Warramunga sediments. The magnetic pattern on the 'ridge' in the vicinity of the Peko shear is considerably more complex than at other points, which would seem to indicate that at least some of the shearing movement took place after the faulting in an intrusion of the magnetic rocks.

There are considerable obstacles to treating the 'ridge' magnetic field analytically. Basically the 'ridge' is an elongated magnetic high on which a number of roughly circular minor anomalies are superimposed. The isolation of the magnetic effects due to any single source require a number of simplifying assumptions to be made, very few of which can be justified rigorously. Profiles used for interpretation were obtained either from the flight lines, or from special lines flown along tracks selected after contouring was completed, or they were constructed from the contour map. The latter method can only be considered satisfactory where the anomaly amplitude is very much larger than the contour interval.

The anomaly most suitable for full analysis occurs about 1/3 mile north of the Susan mine. The three interpretation techniques developed by Moo (1964), were each applied to this body and yielded results within 5% of each other, at approximately 700 ft. below ground level. The Peter's

factor of 1.3, obtained using Moo's methods, suggests that the source is of very limited extent and consequently is not part of the ridge but may be an ironstone body shallower than the ridge. The geological map shows ironstone outcropping near the centre of the anomaly. However there are two reasons for thinking that the source is in fact part of the ridge. Firstly, a north-south constructed profile across the ridge near this smaller anomaly yielded a similar depth when analysed by the simple Peter's method and, secondly, other ironstones in the area, at Susan and Pinnacles, do not affect the aeromagnetic contours. Elsewhere on the 'ridge' depths appear to range from 1300 ft. to as little as 700 ft. below the surface. These fluctuations may be due more to the inaccuracy of the underlying assumptions than to real fluctuations in the depth of the source rocks.

North-east of Peko, within and close to the shear zone, there are a number of small circular magnetic anomalies on the 'ridge'. Near these anomalies high copper concentrations were detected by the geochemical survey, and further investigation may be justified. The northernmost and largest of the magnetic anomalies is centred at approximately 20,000E 2,000N (Plate 3) is about 500 ft. below surface and the anomaly immediately south of it is rather deeper. Only the most general calculations, liable to large errors, could be made in such a complex area.

South of the eastern end of the ridge lie the Golden Forty, Great Eastern and Golden Kangaroo mines and prospects. The associated magnetic anomalies have already been delineated on the ground and the results obtained at Golden Forty and Great Eastern have been published (Daly 1957). Part of the work at Golden Kangaroo, by Australian Development N.L., has also been reported (Douglas 1962). Because of the existing thorough ground coverage no attempt was made to 'fill-in' across the peaks of the anomalies, where the flight lines are rather widely spaced and as a result some of the finer detail of the anomalies, which would normally be shown by a detailed aeromagnetic survey, has been missed.

As already noted, the 'ridge' is abruptly terminated at the Golden Forty lineation which passes between Golden Forty and Golden Kangaroo. The east-west elongated high to the east is possibly caused by a south faulted extension of the 'ridge' material, but two anomalies to the west may indicate economically important ironstones. The first, centred about half a mile north-east of Golden Kangaroo, is caused by a body coming to within 800 ft. of the surface whereas the second source, a little less than a mile farther north, is possibly 100-200 ft shallower. The magnetic pattern associated with this latter body merges into the 'aeromagnetic ridge', but the source rock is more likely to be an ironstone than an extension of the 'ridge' material. Both these postulated ironstones are close to the Golden Forty lineation and may therefore justify further investigation, possibly by geochemical methods.

In the south-east of the area the broad anomaly east of the Joker Mine, already detected in ground surveys (Daly 1957) has been delineated. No explanation of this anomaly has yet been advanced, but the nearby porphyry rocks are a possible source.

In the south-west of the ~~priority I survey~~ area the dominant magnetic feature is a broad complex anomaly approximately 150 gammas in amplitude. There are two major peaks, to the east of the known ironstones between the Southern Star and Pup mines, and of the porphyry outcrop near the Pup. There is no outcrop in the anomalous region. The upper surface of the main source, which is probably pipelike rather than lenticular, is less than 400 ft. below ground level. The western source is possibly slightly nearer the surface.

The source or sources of these anomalies must occupy an area similar in size to that occupied by the Peko or Golden Forty lodes. However the magnetite content must be very much smaller. This would be the case with a number of comparatively small Ironstone bodies, but the comparatively simple shape of the anomaly suggests a more homogenous source carrying disseminated magnetite. Porphyry rocks near Tennant Creek usually contain some magnetite and are known to cause magnetic anomalies, and such rocks are the most likely source of the anomalies east of the Pup.

North Star Area

There is a surprisingly large discrepancy between the detailed aeromagnetic results and the earlier D.C.3 map. Not only is there no indication of the complexity of the anomaly on the D.C.3 contours, which is to be expected in view of the wider line spacing and the greater survey height, but the ~~overall~~ magnetic pattern in the eastern part is quite different. The broad low intensity feature indicated on the detailed map beyond the south-east corner of the survey area, does not extend north along the Stuart Highway, as the earlier contours would suggest. Profiles obtained by the Cessna show that the North Star - Northern Star anomaly is positioned on a gentle magnetic slope, rising to the west, and not in a trough as shown on the D.C.3 map. No explanation of the discrepancy is apparent at the moment.

The detailed aeromagnetic contours were also compared with the ground magnetic contours obtained by the A.G.G.S.N.A. (Daly 1957). The ground survey covered the eastern end of the main anomaly and the minor anomaly to the north-east, but traverses near the peak of the aeromagnetic anomaly were too disturbed to allow contouring. As might be expected the pronounced eastern 'tail' of the main anomaly was resolved into a definite second peak by the ground work.

The position and extent of the main low associated with the main high suggest a body dipping fairly steeply to the north. The dip angle cannot be reliably estimated but is probably in the region of 60°. The main source is between 300 and 500 ft below ground, the source of the smaller anomaly to the north-east, about 350 ft below ground.

The anomalies are located on the steepest part of a north-east striking magnetic slope, which possibly indicates a fault contact in the Warramunga sediments or in the underlying basement rocks. Such a fault zone could have controlled mineralisation. No magnetic anomalies are associated with the quartz-hematite bodies cropping out at the southern border of the survey area, due south of the North Star and Northern Star leases.

The geochemical sampling programme at North Star involved the hammer drilling of forty-four holes, totalling 3,000 ft, as well as stream and outcrop sampling. Copper concentrations in drill samples were generally high,

up to 10,000 p.p.m. Unfortunately the drilling programme stopped south and east of the peak of the main aeromagnetic anomaly, which is near the Northern Star open cut. The highest copper concentrations were obtained in holes drilled in the ironstone outcrop south-east of the open cut. The orebody mined at Northern Star was faulted out at about 250 ft. below surface by an apparently horizontal movement. The ironstone crops out south and east of the open cut and is thought to dip northwards.

The eastern end of the main aeromagnetic anomaly, which is a distinct ground anomaly, ~~and~~ has been prospected by a number of diamond drill holes. Good gold ore has been intersected at about 900 ft. in one of these holes, and copper ore in another at a similar depth. In view of the previous results in the area, further work on the main aeromagnetic anomaly would seem to be justified.

The north-eastern anomaly has also been investigated, but no significant results are reported.

Gigantic Area

The Gigantic anomaly delineated by the D.C.3 aeromagnetic map is resolved by the more detailed Cessna survey into two major anomalies. There is general agreement between the results of the two surveys, as distinct from the North Star area, and merely evidence of the better resolving power of the more detailed survey.

The contour mapfor North Star and Gigantic show a remarkable similarity. In both areas the main anomaly is positioned on a gentle magnetic slope, in the case of Gigantic however the slope is to the ~~south~~ north-west. The position and extent of the main low, associated with the main high, suggest, as in the North Star area, a body dipping steeply to the north. Calculation of the dip angle is not considered reliable but it is estimated to be in the region of 60°. Depth estimates on the main high suggest the source is somewhere between 100-150 ft. below ground level, and the source of the other major anomaly to the south-east is estimated at about 100 ft. below ground level. These are unusually shallow depths for magnetic sources in the Tennant Creek field, and possible indicate lenticular rather than dykelike

sources, at greater depths.

The area is shown on the geological map with outcropping quartz-hematite-magnetite and this is probably the source of the anomaly. No geochemical drilling was carried out in the Gigantic area by the B.M.R. Geologists.

The contour map also shows some minor anomalies to the north-east and south-east of the major anomalies and there is in general a slight disturbance of the contour pattern around and to the north-east of the major anomalies. This may be due to the Peko Shear which is thought to extend as far as Gigantic but the effect on the contours is by no means as obvious as in the case of Aeromagnetic Ridge.

Conclusions

The survey showed that the detailed aeromagnetic method is applicable to the Tennant Creek Mineral Field and that 'major type anomalies' (Daly 1957) are detected and are defined quite closely. A small amount of ground follow-up work would be necessary in most cases prior to the selection of sites for drill holes.

One of the aims of the detailed survey was to find out to what extent geological structure could be determined from the magnetic results. In general the Tennant Creek area appears to be too complex for much correlation between magnetic contours and the observed geology to be apparent. Such correlations are possible in the case of the Peko shear and the Golden Forty lineation, and of the north-east striking magnetic contours at North Star. However, although the effects of known shear zones may be noted it seems unlikely that many new shears will be identified from the magnetic data.

Diamond drilling of anomalies on the 'aeromagnetic ridge' may be justified on academic grounds, but is unlikely to reveal economic mineralisation. The anomaly at 20,000E, 2,000N (geochemical grid coordinates) is recommended if a target is required, since the source is close to both the Peko shear and to small geochemical anomalies, and is nearer surface than most of the other 'ridge' material. Before drilling a limited amount of ground magnetic work could be carried out to locate the peak. It is suggested that the drill hole be vertical and situated about 200 ft. south of the ground located peak,

to permit intersection of the source even if it proves to be lenticular, not prismatic.

Minor anomalies north of Golden Kangaroo may be related to economic mineral deposits. This possibility could be tested in the first instance by geochemical surveys.

The main aeromagnetic anomaly at the North Star has not, as far as is known, been tested at depth. Extension of the geochemical survey into this area would be necessary before selecting targets for deep drilling.

No recommendations can be made with regard to the Gigantic, since it is not known to what extent this prospect has been tested by private companies, but geochemical surveying would seem to be an obvious first step.

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APPENDIX

OPERATIONAL DETAILS

1. Survey specifications

Height: Nominally 280 ft a.g.l. for the aircraft and 250 ft a.g.l. for the detector (in towed bird assembly).

Line spacing: Nominally 1/10 mile.

Flight direction: East or west. Since most flights took place in the early morning, the majority of lines were flown west, away from the sun.

Sensitivity: (Magnetometer) 100 γ F.S.D. and 10,000 γ F.S.D. on separate recorders.

2. Equipment

Aircraft: Cessna 180.

Magnetometer: MNS1 nuclear precession magnetometer, reading total absolute field at half second intervals, fiducial pulses occurring at four second intervals.

Recorders (Magnetometer): Moseley. Chart, 6" rectilinear, chart speed 4"/min.

Radio Altimeter: A.P.N.1 with outputs to cockpit dial and limit light system, and to recorder.

Recorder (Radio Altimeter): T.I.C. Chart 6" curvilinear.

Camera: Modified Vinten with wide angle (186°) lens. One exposure on 35 mm. film every four seconds.

3. Personnel

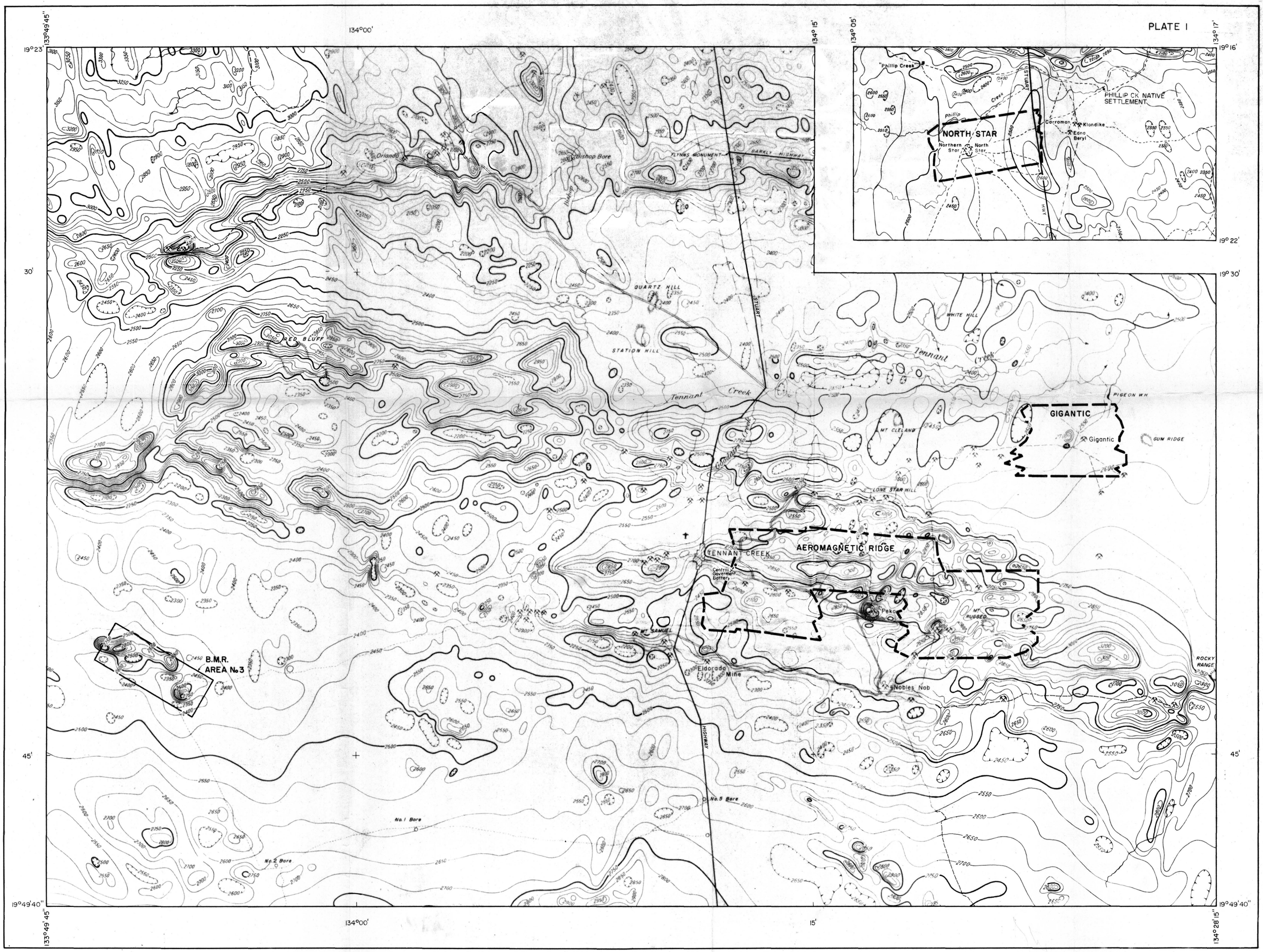
B.M.R.: C. Braybrook, R. Buckley, W. Finney, J. Milsom, S. Schorl, B. Tregellas.

T.A.A.: F/O G. Litchfield.

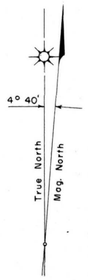
4. Operations

The road party arrived in Tennant Creek on the 31st of August and departed for Bachelor on the 30th of September. The aircraft arrived in Tennant Creek on the 1st of September and left for a service in Alice Springs on the 28th of September.

PLATE I



LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS

	HAYWARD CREEK	BRUNCHILLY CREEK SOUTH
MARION ROSS	MT WOODCOCK	WARRAMUNGA
RED BLUFF	TENNANT CREEK	GOSSE RIVER
	BOONS	GOSSE RIVER SOUTH

DETAILED AEROMAGNETIC SURVEY, TENNANT CREEK, NT 1964

LOCALITY MAP

TOTAL MAGNETIC INTENSITY CONTOURS, AFTER B.M.R. AEROMAGNETIC SURVEYS 1956 AND 1960

MILES 2 0 2 4 6 8 10 MILES

KILOMETRES 2 0 2 4 6 8 10 12 14 KILOMETRES

(CONTOUR INTERVAL 50 GAMMAS)

LEGEND

TOPOGRAPHICAL DATA

- River or creek
- Highway or main road
- Secondary road
- Road or track
- Telegraph line
- Bore
- Mine
- Aerodrome or landing ground
- Hill feature

MAGNETIC DATA

- 2000 / 1900 Magnetic contours
- Magnetic "Low"
- Detailed Aeromagnetic Survey Boundary

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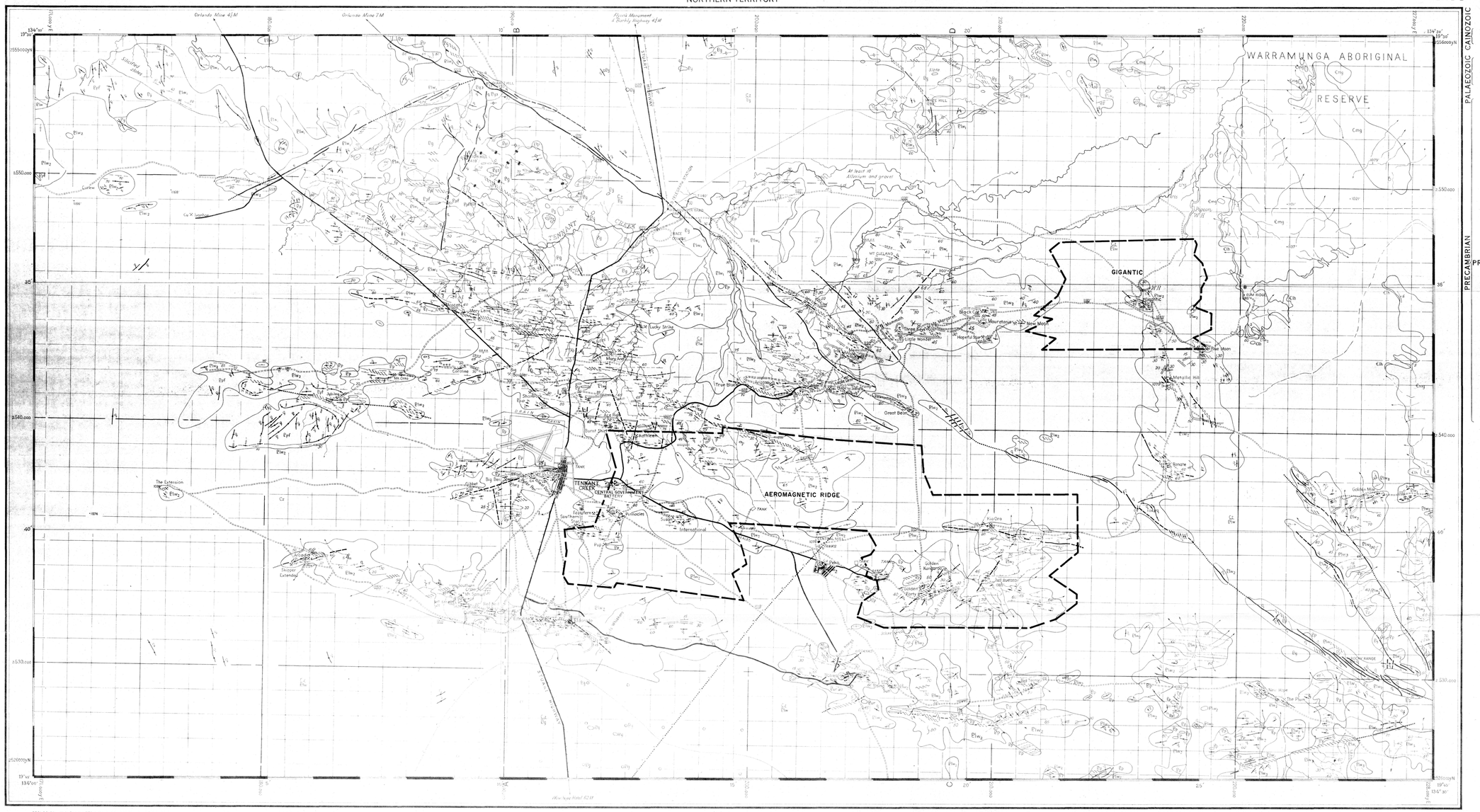
TENNANT CREEK
NORTHERN TERRITORY



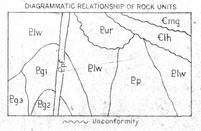
GEOLOGICAL AND PLANIMETRIC MAPPING AFTER 1 MILE GEOLOGICAL SERIES SHEET 238 ZONE 5, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.
TRANSVERSE MERCATOR PROJECTION.

Reference

Era	Period	Unit	Symbol	Description
PALAEOZOIC CAINOZOIC			Cz	Alluvium, gravel, sand, silt, clay (bulldust)
PALAEOZOIC	CAMBRIAN	MIDDLE: Gum Ridge Formation	Cmg	Calcareous sandstone, shale, chert
		LOWER: Helen Springs Volcanics	Clh	Lavas, pyroclasts
PRECAMBRIAN	PROTEROZOIC	UPPER: Rising Sun Conglomerate	Pur	Conglomerate, quartzite, sandstone, shale
		UPPER & LOWER	q	Quartz
			l	Lamprophyre
			h	Quartz-hematite-magnetite
			j	Hematite jasper
			p	Porphyry
			pq	Quartz-baveno-porphyry
			d	Dolerite
			di	Diorite
			s	Serpentine
		LOWER	Pp	Quartz-feldspar-porphyry
			PpF	Quartz-baveno feldspar-porphyry
			Pg3	Fine-grained granite
			Pg2	Foliated coarse-grained porphyritic granite
			Pg1	Coarse-grained granite
			Pg	Porphyritic granite (foliated in places)
		Warramunga Group	Plw3	Greywacke, shale; Hematite shale
			Plw2	Sandstone, shale, siltstone
			Plw1	Pebble beds
			Plw1	Pebble beds; Shale, some greywacke

Geological boundary
Anticline, showing plunge
Syncline
Fault
Where location of boundaries, faults and folds is approximate, line is broken; where inferred, queried, where concealed, boundaries and folds are dotted, faults are shown by short dashes
Strike and dip of strata
Vertical strata
Horizontal strata
Overturned strata
Trend of bedding, showing direction of dip
General strike and dip of undulating strata
Platy flow, vertical
Platy flow inclined
Strike and dip of foliation
Plunge of drag fold
Plunge of minor anticline
Shear zone
Vertical joint
Major gold mine
Gold mine
Bismuth
Copper
Battery
Bore
Macrofossil locality
Highway
Road
Vehicle track
Telegraph line
Windmill
Tank
Yard
Building
Radio mast
Dam
Waterhole
Height in feet, instrument levelled
Height in feet, barometric
Datum: mean sea level
Detailed Aeromagnetic Survey Boundary

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



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	BOONE	GOSSE RIVER SOUTH

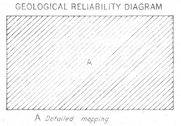
True North
Mag North

DETAILED AEROMAGNETIC SURVEY, TENNANT CREEK, NT 1964

GEOLOGY

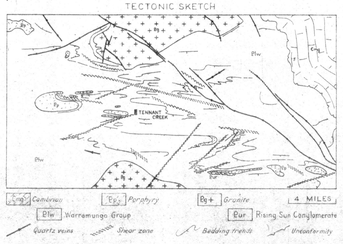
MILES 1 0 1 2 3 4 5 MILES
KILOMETRES 1 0 1 2 3 4 5 6 7 KILOMETRES

GEOLOGICAL RELIABILITY DIAGRAM



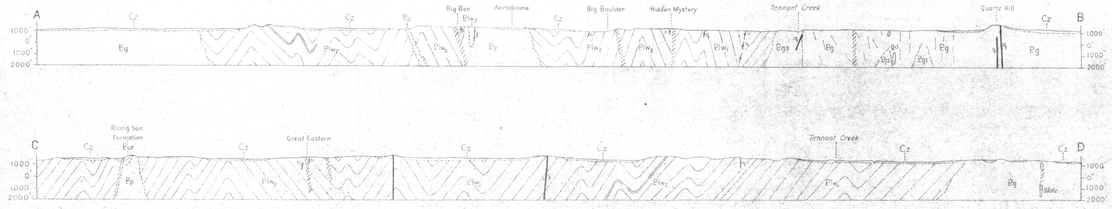
A Detailed mapping

TECTONIC SKETCH



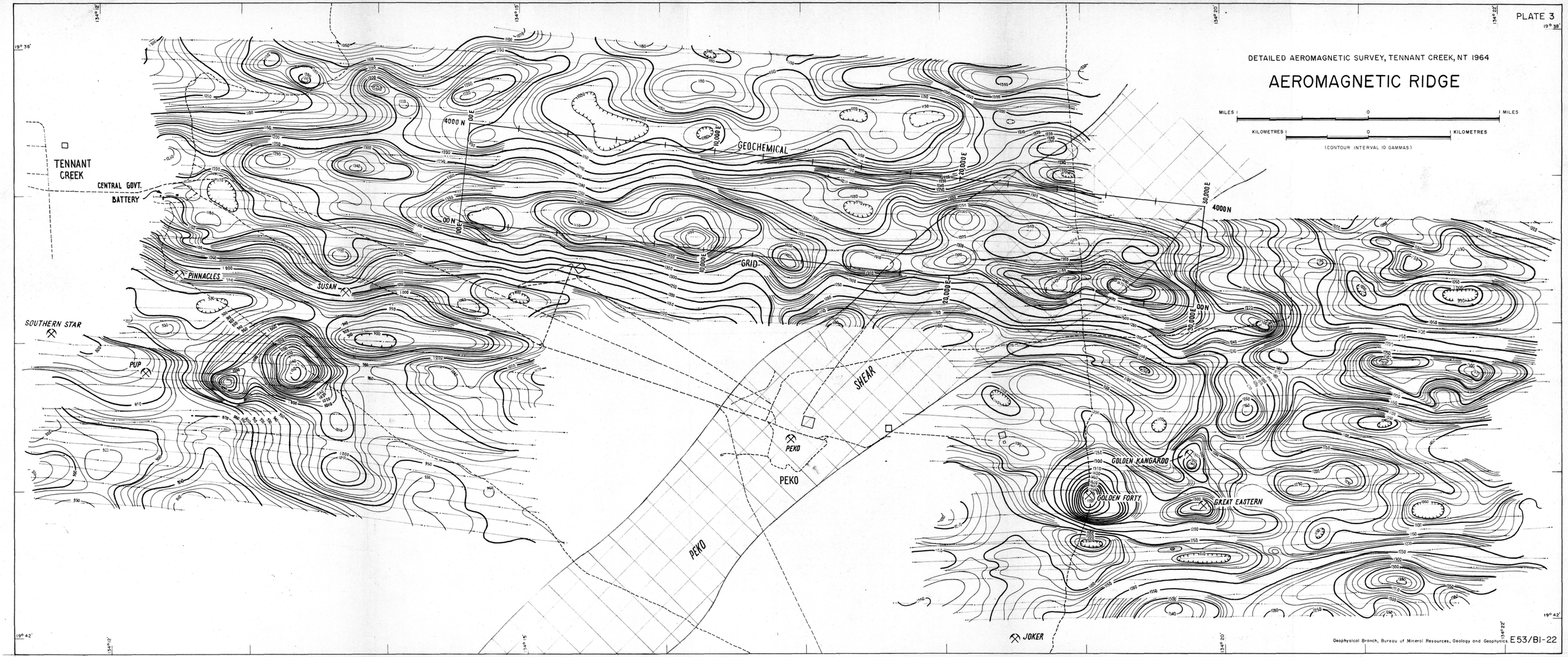
LOCATION DIAGRAM

Sections
Folding diagrammatic
Scale: $\frac{V}{H} = 1$



DETAILED AEROMAGNETIC SURVEY, TENNANT CREEK, NT 1964

AEROMAGNETIC RIDGE



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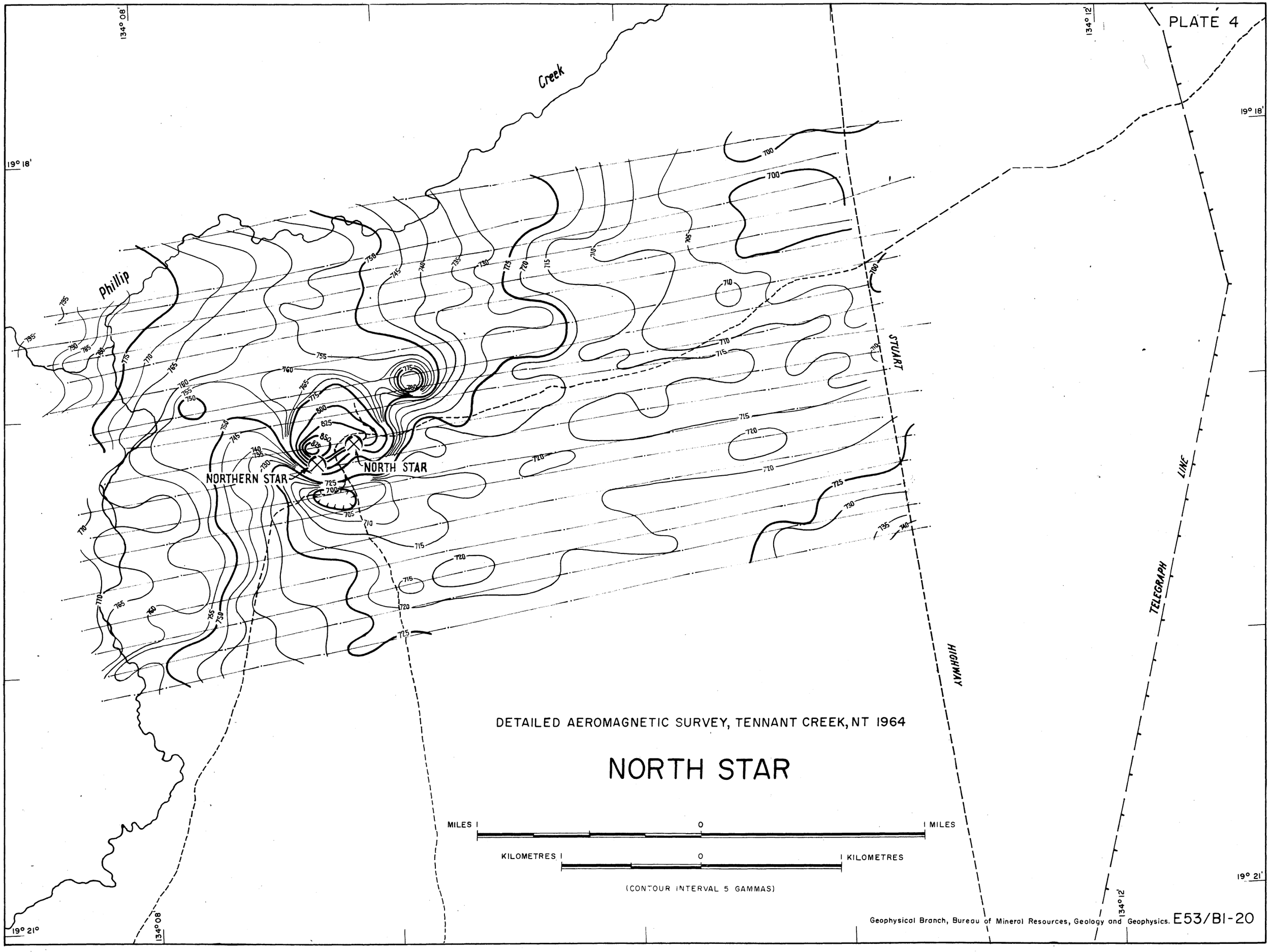
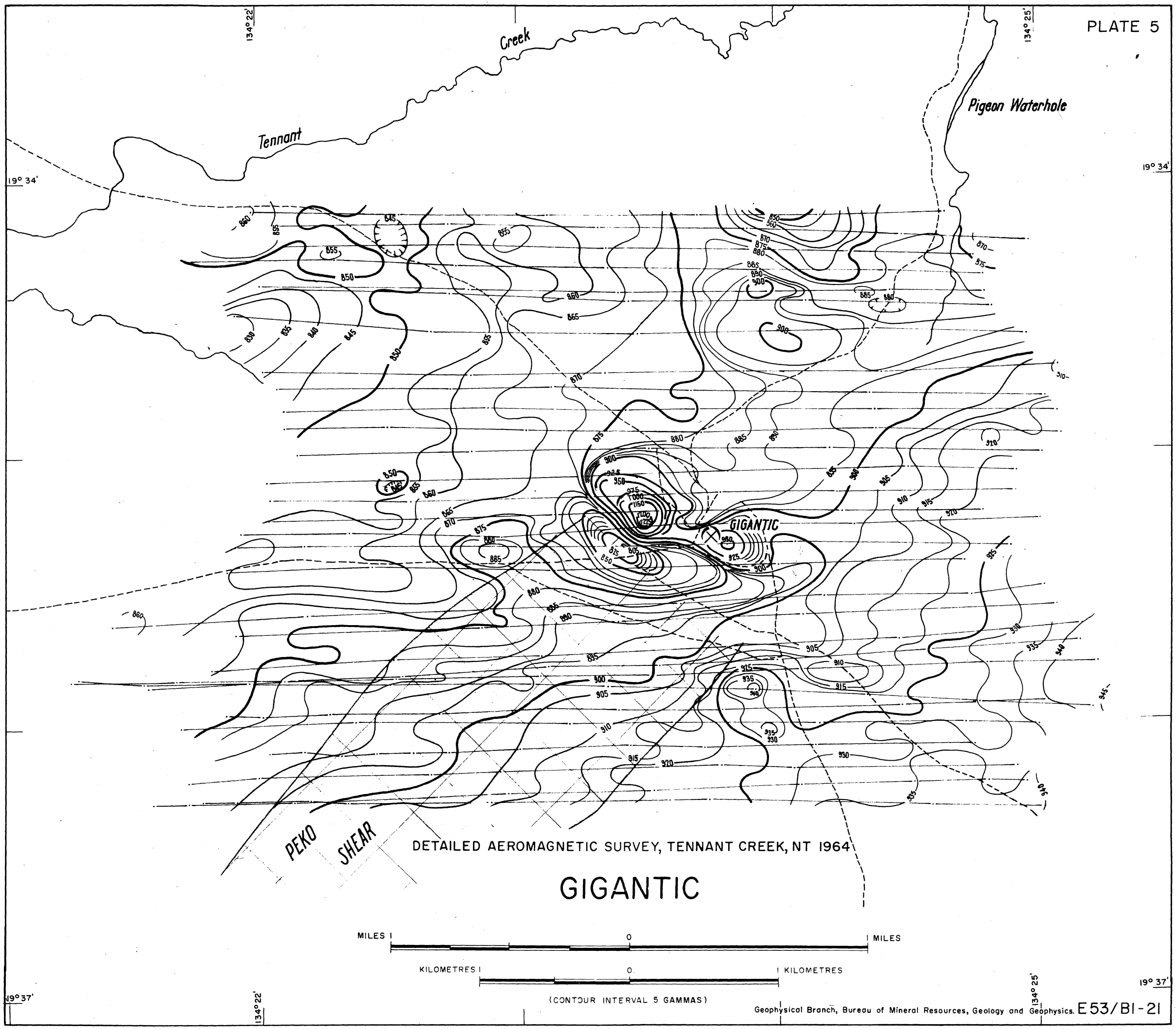


PLATE 4
Creek
Phillip
NORTHERN STAR
NORTH STAR
STUART
HIGHWAY
TELEGRAPH
LINE
134° 08'
134° 12'
19° 18'
19° 21'
DETAILED AEROMAGNETIC SURVEY, TENNANT CREEK, NT 1964
NORTH STAR
MILES 1 0 1 MILES
KILOMETRES 1 0 1 KILOMETRES
(CONTOUR INTERVAL 5 GAMMAS)
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. E53/B1-20

PLATE 5



DETAILED AEROMAGNETIC SURVEY, TENNANT CREEK, NT 1964

GIGANTIC

(CONTOUR INTERVAL 5 GAMMAS)

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