DEPARTMENT OF
MINERALS AND ENERGY

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



Record 1974/80



## GROUND GEOPHYSICAL SURVEY
## TENNANT CREEK, NORTHERN TERRITORY, 1971.

by

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CONTENTS



ILLUSTRATIONS

## SUMMARY

In 1971 ground magnetic and gravity surveys were made over selected aeromagnetic anomalies in the Tennant Creek mineral field to re-evaluate anomalies previously investigated (C6, C8, C11, C12) and to investigate in detail aeromagnetic anomalies at and to the west of Mary Ann. In addition, a regional magnetic and gravity survey was made on line 9600E to investigate further the Aeromagnetic Ridge, gravity coverage at the Comet prospect was extended, and test gradient magnetic measurements were made at C6 and the Aeromagnetic Ridge.

The interpreted results show satisfactory correlation between geophysical and drilling results at C6, C8, C11, and C12 and indicate extensions at depth of bodies at C6 and C11.

No correlation was found between magnetic and gravity anomalies at Mary Ann, and the anomalies are considered to be related to regional features.

The results from the Aeromagnetic Ridge and the Comet prospect were inconclusive.

The gradient magnetic measurements yielded useful additional information for interpretation; noise problems were the most serious limitations to the work.

Drill holes have been recommended at C6 and C11 to test anomalies and to locate extensions of bodies. Stratigraphic drill holes have been recommended at Mary Ann and the Aeromagnetic Ridge.

# 1. INTRODUCTION

At the request of the Mines Branch, Northern Territory Administration, the Bureau of Mineral Resources, Geology and Geophysics, (BMR) carried out ground magnetic and gravity surveys in the Tennant Creek area from August to October, 1971. The two main survey objectives were a re-evaluation of magnetic anomalies C6, C8, C11, and C12 investig magnetic anomalies C6, C8, C11, and C12, and the delineation and interpretation of aeromagnetic anomalies at, and to the west of, Mary Ann. In addition, a regional gravity and magnetic traverse was surveyed along line 9600E to investigate further the Aeromagnetic Ridge; gravity coverage of the Comet prospect was extended; and a new technique, gradient magnetic measurements, was tested at Area C6 and at selected localities along the Aeromagnetic Ridge. The areas surveyed are shown in relation to the township of Tennant Creek in Plate 1.

Two main mining companies operate near Tennant Creek: Australian Development Ltd (Nobles Nob Mine), and Peko Wallsend Ltd (Peko, Juno, Orlando, Ivanhoe, Warrego, and Gecko Mines).

The survey party consisted of I. Hone (geophysicist), H. Reith (T.A. 2), P. Bryan (T.A. 2), and one field hand, E. Sedmik and P. Bullock (geophysicists) were present for 3 weeks. Surveying was done by P. Bryan assisted by H. Reith and the field hand.

At times it was necessary to have access to Authorities to Prospect held by Peko Wallsend Ltd and Australian Development Ltd. The co-operation of these companies is gratefully acknowledged. The co-operation of officers of the Mines Branch, Northern Territory Administration, is also gratefully acknowledged.

# 2. GEOLOGY

The geology of the Tennant Creek field has been described by Ivanac (1954), Crohn (1963), Crohn & Oldershaw (1965), and Dunnet & Harding (1967). Comprehensive summaries are given by Finney (1967) and Shelley & Browne-Cooper (1967). None of the mining companies working in the field have yet published any detailed results of their efforts.

Most of the area is underlain by Lower Proterozoic sediments of the Warramunga Group, which are intruded by acidic and basic rocks and contain ironstone lodes whose origin is not clear. The ironstone lodes consist of quartz, magnetite, and hematite in varying proportions and appear to be controlled by favourable beds and shear zones. Gold, copper, and bismuth mineralization is commonly associated with them.

A number of major mines operate around Tennant Creek. The major gold producers are Nobles Nob and Juno; Peko, Orlando, Ivanhoe, and Warrego are predominantly copper producers. The ore remaining in Ivanhoe is of low grade and is not under constant production. The Gecko Mine (mainly copper) is being developed.

## 3. PREVIOUS GEOPHYSICAL SURVEYS

The first geophysical investigation of the area was carried out in 1935-1937 during the Aerial, Geological and Geophysical Survey of Northern Australia, the results of which have been discussed in detail by Daly (1957). Since then, geophysics, in particular the magnetic method, has been important in exploration; the discovery of the Orlando, Ivanhoe, and Warrego orebodies and the main orebody at Peko can be attributed to geophysical work.

Between 1956 and 1960 the Bureau of Mineral Resources covered the entire Tennant Creek 1:250 000 Sheet area with semi-detailed aeromagnetic and radiometric surveys. Most subsequent geophysical investigations have been based on anomalies delineated by these surveys and by more detailed aeromagnetic surveys flown over selected areas.

Of the areas relevant to the present survey, C6, C8, C11, and C12 were surveyed by Haigh in 1967 (Haigh, 1969a) and 14 000 ft of traverse 9600E over the Aeromagnetic Ridge was surveyed in 1969 (Williams, in prep.). All areas surveyed in 1971 have been covered by detailed aeromagnetic surveys.

## 4. GEOPHYSICAL METHODS

Geophysical work completed in 1971 in many respects complemented earlier work by Haigh and Williams. Accordingly, the current status of geophysical methods applied in the respective survey areas is shown in Table 1.

Instruments used during the survey included a Sander proton precession magnetometer, an ABEM MZ-4 torsion magnetometer, and a McPhar M700 fluxgate magnetometer with horizontal head attachment for measurements of the total, vertical, and horizontal components of magnetic intensity. In addition, a Worden (No. 260A) gravimeter (scale value 0.109 mg/s.d) was used for gravity readings.

Table 1

| Geophysical Method / Area | Magnetic Intensity | | | Vertical Gradient of Total Magnetic Field | Gravity |
|---|---|---|---|---|---|
| | Total | Vertical | Horizontal | | |
| C6 | III | I, III | III | III | III |
| C8 | III | I | | III | |
| C11 | III | I, III | III | III | III |
| C12 | III | I, III | III | III | I,III |
| AR2 | III | II | II | III | |
| Comet | III | II | | III | II,III |
| AR6 | III | II | | III | |
| Mary Ann | | III | III | | III |
| Line 9600E | III | II, III | II | | II,III |

I : J. Haigh   II : J. Williams   III : I. Hone

The Sander and ABEM magnetometers could be read with an accuracy of ± 1 gamma. The McPhar instrument by contrast could only be read with an optimum accuracy of ± 5 gammas, and misorientation of ± 1 degree increased errors to ± 20 gammas. For this reason, horizontal magnetic field profiles in general appear noisy.

Gradient measurements were obtained by taking readings of the total magnetic field at heights of 6 feet and 14 feet above the ground, and dividing the gamma difference by the height variation (8 feet). The gradient was deemed positive if the magnetic intensity at the higher level was less than that at the lower level.

## 5. COMPUTATION AND INTERPRETATION PROCEDURES

### Magnetic Method

Components of magnetic intensity. Drift corrections were applied and the results plotted as profiles or contours where appropriate. Quantitative interpretation was achieved mainly by curve-matching methods with reference to theoretically derived standard curves for thin and thick infinite dykes (Gay, 1963), finite dykes (Haigh & Smith, in press.) and spheres (Haigh, 1969b). Limited use was also made of Daly's method for interpretation of total field anomalies attributable to spheres (Daly, 1957).

The biggest problem in magnetic interpretation is that only rarely is an anomaly simple, attributable to a regular single body in a uniform background field. Usually the effect of a magnetic body is superimposed upon the effects of adjacent bodies, changes in the depth to basement, and variations in the magnetic properties of the host rock. Interpretation of magnetic data rarely yields a unique solution. Estimates of susceptibility can be obtained for interpretations which involve thick dyke models, but are generally too small. For an interpretation which involves a spherical model, the radius of the body can be calculated by assuming various susceptibility values.

Vertical gradient of total magnetic field. No account has previously been published of the application of magnetic vertical gradient measurements to mineral exploration at Tennant Creek. Gradient measurements produce sharper anomalies than total magnetic field measurements, so the interfering effects of adjacent bodies are reduced. The influence of a regional magnetic gradient is also decreased and drift corrections do not have to be applied in data reduction. Unfortunately two factors limit the application of the method: the small amplitudes of anomalies commonly recorded, and increased disturbance effects (noise) caused by shallow concentrations of strongly magnetic material.

The maximum gradient anomaly from a point dipole is

$$\frac{3\Delta Tmax}{h}$$

where $\Delta$ Tmax is the maximum total field anomaly and h the depth to the point dipole. Thus a small ironstone mass at 30 feet depth which produces a total field anomaly of 20 gammas will give a maximum gradient of 2 gamma/ft. This is similar to the maximum gradient from a point dipole at a depth of 600 feet which produces a total field anomaly of 400 gammas at the surface.

In most cases, the magnetic gradient profiles were too noisy for quantitative interpretation. Where possible, however, less noisy profiles were smoothed and interpreted by the method of Slack, Lynch, & Langan (1967), which uses Euler's relationship and requires total field data in addition to gradient data.

Euler's relationship is:

$$x\frac{\partial T}{\partial x} + y\frac{\partial T}{\partial y} + z\frac{\partial T}{\partial z} = -nT$$

where x, y are distances measured horizontally along the x and y axes from the centre of the anomalous structure;

z is the depth of the body;

$\frac{\partial T}{\partial x}$, $\frac{\partial T}{\partial y}$ are the slopes of the magnetic anomaly as measured along the horizontal x and y axes;

$\frac{\partial T}{\partial z}$ is the vertical gradient;

T is the magnitude of the magnetic anomaly at any point (x,y,z);

n is a constant, depending on body geometry (= 2 for a horizontal cylinder, = 3 for a sphere).

At the peak of the total field anomaly $\frac{\partial T}{\partial x} = 0$. If axes are selected so that y = 0, the relationship in difference form for numerical calculations is

$$z\frac{\Delta T}{\Delta z} = -nT$$

$$\text{or} \quad T/(\Delta T/\Delta z) = -z/n$$

Directly over the top of the body, x like y = 0.

Thus,

$$T/(\Delta T/\Delta z) = -z/n$$

Hence by calculating $T/(\Delta T/\Delta z)$ at the peak of the total field anomaly and finding another point such that $T/(\Delta T/\Delta z)$ is similar, the centre of the structure can be found.

By the determination of $x, \Delta T/\Delta x, \Delta T/\Delta z$, and T at a number of points on the anomaly curves, graphical solutions for z and n can be found. Because of noise, a scatter of values for z and n usually results.

GRAVITY METHOD

Gravity readings were corrected for instrument drift and latitude effects. Bouguer anomalies were calculated using a density of 2.60 $g/cm^3$ as recommended by Haigh (1969a). Anomalies were interpreted by the application of computing methods developed by Talwani & Ewing (1960) and Cull (1971).

## 6. DISCUSSION OF RESULTS

In 1967 the Bureau of Mineral Resources flew a detailed low-level aeromagnetic survey over Area C (Shelley & Browne-Cooper, 1967). Anomalies delineated were followed up on the ground later in the year (Haigh, 1969a). Anomalies C6, C8, C11, and C12 were further evaluated in 1971. Accordingly, the reader is referred to plates 17 and 19 of Haigh (1969a), which show detailed traverse plans and aeromagnetic contours appropriate to these localities.

Area C6

Vertical magnetic intensity readings were obtained by Haigh over traverses 800W, 1200W, and 1600W. He interpreted the anomaly as being due to a spherical body with centre 320 feet below 6140N, and on his recommendation DDH5 was drilled from 1200W/6000N, depressed at 50° towards 0° magnetic. This intersected ironstone and a further six holes were drilled, which all intersected ironstone. The aim of the additional work at C6 in 1971 was to gain more information on the known body to determine whether any further drilling appeared warranted.

Vertical, horizontal, and total magnetic field and gravity readings were obtained on lines 800W, 1200W, and 1600W. In addition, magnetic gradient and gravity readings were obtained from 800W to 2400W, over and to the west of the main anomaly, and a gravity cross-traverse was read along 6300N from 3500W to 1500E.

The magnetic interpretations assuming a spherical body gave very similar results to those of Haigh as summarized in Table 2.

Table 2

| INTERPRETATION OF MAGNETIC INTENSITY DATA<br>ANOMALY C6 1200W | | | | |
|---|---|---|---|---|
| COMPONENT | BODY | LOCATION | DEPTH (feet) | REMARKS |
| Vertical | Sphere | 6140N | 320 | Same model as used by Haigh<br>Radius in ft. — Susceptibility in c.g.s. units<br>105 — 0.1<br>140 — 0.05<br>170 — 0.03<br>185 — 0.02<br>240 — 0.01 |
| Horizontal | Sphere | 6140N | 333 | |
| Total | Sphere | 6144N | 330 | |

Plate 2 shows the results of diamond drilling on traverse 1200W and an alternative interpretation of the total magnetic field data involving a vertical prismatic (pipe-like) body with sides 260 feet in length and depth of 130 feet to the upper surface. An excellent curve fit is achieved assuming a total magnetic field inclination of $-60^{\circ}$. As the field inclination at Tennant Creek is only $-49^{\circ}$, acceptance of this solution requires a significant contribution of remanent magnetism to the total magnetization of the body.

The calculated Bouguer anomaly generated by a similar body - a vertical pipe of 100 feet radius, 100 feet depth to upper surface, and 700 feet depth to lower surface - is also shown in Plate 2 in relation to field observations. The close agreement of theoretical and observed gravity data is indicative of an acceptable choice of model, and leaves little doubt that the ironstone intersected by DDH5 and DDH5A is pipe-like.

The two broader Bouguer anomalies evident in the gravity profile have no counterparts in the magnetic data. Their sources, therefore, must be related to relatively wide lithological units of low magnetite content.

The magnetic gradient measurements were too noisy for quantitative interpretation; however, they were adequate for data presentation in contour form as shown in Plate 3. It appears that the drilled ironstone mass plunges to the north-northeast with little extension to the south. A small area of positive gradient exists to the southwest of this body, centred at 1900W/6000N; a small total magnetic field high also occurs in this region.

The full gravity results illustrated in Plate 4 indicate that the ironstone has little extension beyond the outline defined by drilling. A gravity ridge extends WSW through the main gravity high and includes the previously-mentioned small area of higher magnetic gradient. Geology shown in Plate 5 is by Willis & Daly (1972) and indicates that sheared porphyry underlies both the magnetic and gravity anomalous zones; so magnetite may well have been introduced regionally into the unit, attaining massive proportions at two localities.

Area C8

Three traverses, 400W, 0, and 400E, were surveyed by Haigh in 1967. Profiles obtained of vertical magnetic intensity were too disturbed for interpretation; accordingly total field measurements were obtained in 1971 for gradient analysis. Noise problems again proved insurmountable for quantitative work, so data have been presented in contour form as total magnetic intensity at the two observation levels (Plate 6). At the 14 feet level, a smoother picture was obtained, from which it is evident that an anomaly strikes at about 060° magnetic through 2000N/00. The magnetic profile constructed along AA' and its interpretation are shown in Plate 7. As only three traverse were read and the constructed profile could not be located through the centre of the anomaly, drilling recommendations in the absence of any geological control are hazardous. The optimum test of the magnetic feature as defined would be a vertical hole to 300 feet drilled at 1600N/400W.

Area C11

As a result of a vertical magnetic intensity survey by Haigh of traverses 400W, 0, and 400E, six holes were recommended for drilling. These were drilled by the Mines and Water Resources Branch, Northern Territory Administration and followed by 24 further holes designed to define the extent and mineral potential of an ironstone body intersected in three of the first holes. Drilling information now indicates that the ironstone body has a mushroom shape and reaches to within 5 to 25 feet of the surface. Wagon drill hole No. 5 was still in ironstone when completed at 190 feet. Assay results showed weak mineralization.

Horizontal, vertical, and total magnetic intensity, magnetic gradient, and gravity measurements were obtained on Traverse 0 during the 1971 survey. The horizontal intensity and gradient profiles proved to be too noisy for interpretation and are not shown. Interpretation of the total field profile at the 14 foot level indicates the presence of a thick dyke-like body at a depth of 22 feet below the surface (Plate 8). The vertical field profile is noisier than the total field and interpretation accordingly more ambiguous. Nevertheless, interpretation of this does indicate a body compatible with the former interpretation (Plate 9). In both interpretations, only the central part of the anomaly peak was used for interpretation. More complete analyses of the entire anomaly forms would yield interpretations wherein the main mass of the ironstone body was at a slightly greater depth with minor extensions to a shallow depth.

The gravity profile indicates an anomaly of over two milligals centred at 1200N as shown in Plate 10. Assuming a density of 2.6 g/cm$^3$ for the country rock and 4.7 g/cm$^3$ for the ironstone (a quartz-magnetite-hematite body), a theoretical anomaly was determined for the ironstone mass as established by drilling, using the method of Talwani & Ewing (1960). It was assumed that the body does not extend deeper than 190 feet. The calculated anomaly was less than that observed, implying an extension of ironstone not detected by drilling. Subtraction of the theoretical anomaly from the observed produces a complex residual, the greater part of which is located to the northern side of the drilled body. Interpretations for the residual anomaly involving spherical mass distributions are shown in the lower diagram of Plate 10. The choice of this model was made as a result of the analysis of aeromagnetic data by Shelley & Browne-Cooper (1967) wherein they attributed the C11 anomaly to a sphere reaching to within 500 feet of the surface. This earlier magnetic interpretation is suspect in the light of later ground magnetic data. A more plausible interpretation to meet all known geophysical and drilling data would be a pipe-like ironstone mass which extends from the drilling limits through the spherical models shown in Plate 10. To remove an apparent conflict between dip of this hypothetical body and magnetic data, remanent magnetization of the ironstone would have to exist.

Area C12

From vertical magnetic field data, Haigh interpreted anomaly C12 as being due to a thin dyke, apex at 1650N, depth 200 feet, and with a dip of 60°S. On his recommendation, a diamond drill hole was collared at 3600E, 1440N and drilled at a depression of 60° in a direction of 0° magnetic. Some magnetite was intersected at a vertical depth of 360 feet but the main intersection was at a vertical depth of 520 feet and below.

Vertical, horizontal, and total field magnetic, gradient magnetic, and gravity data were obtained on traverse 3600E during the 1971 survey. The vertical magnetic field profile produced was almost identical with that recorded by Haigh (Plate 21, Haigh 1969a) and the same interpretation thereby obtained. The interpretation of horizontal and total magnetic field curves as shown in Plates 11 and 12 gave similar results to that obtained from the vertical magnetic field, the significance of the changes in dip and body width being minimal. Interpretation of the gradient data indicated a dyke at a slightly greater depth (260 feet) with apex at 1675N. The gravity data revealed only a small high over 1700N.

Mary Ann

The BMR covered the Mary Ann area with a detailed low-level aeromagnetic survey in 1966 (Finney, 1967). The Mary Ann mine, which is contained within an iron-impregnated shear zone trending 100° and has a recorded production of 180 oz of gold (Crohn & Oldershaw, 1965), was seen to be located on the flank of a long easterly trending aeromagnetic high (Plate 13).

Vertical magnetic field measurements were obtained on three traverses in 1971, as also shown in Plate 13. Traverse 11200E proved to be optimum for interpretation and complementary horizontal magnetic field and gravity readings were also recorded.

Shallow magnetic material produced noisy magnetic readings at the southern ends of the traverses. Nevertheless, interpretation of the magnetic data indicated a moderately deep, gently dipping thick dyke-like body located approximately 1000 feet south of the mine (Plates 14, 15). The gravity data (Plate 16) revealed three anomalies, the Mary Ann mine lying on the southern flank of the largest (0.6 mgals).

It is possible to model the largest anomaly approximately by a tabular body of 800 feet width, 2000 feet depth extent and density contrast of approximately 0.1 $g/cm^3$ as shown in Plate 16. This interpretation is aimed at producing a lithological solution for the geophysical data, of the type previously mentioned for the C6 area, as again the magnetic data do not indicate the presence of an anomaly coincident with a gravity feature.

The aeromagnetic survey referred to above revealed the culmination of the elongated magnetic anomaly to the west of the Mary Ann mine. This anomaly was investigated in 1971 by obtaining vertical magnetic field readings over 4 traverses as shown in Plate 13. Horizontal magnetic field readings and gravity readings were also recorded on 8000E, the traverse mainly used for interpretation.

In general, the magnetic results were difficult to interpret, as evidenced by Plate 17, which shows vertical field data. Obviously the dyke solution shown at a depth of 500 feet is suspect. No solution was obtained for the horizontal field data.

The gravity data (Plate 18) again revealed a fairly broad anomaly of 0.6 mgals to the north of the magnetic anomaly, in this case centred near 600 N. The similarity between the two gravity profiles through 8000E and 11200E is indicative of a relatively simple geological solution related to stratigraphy. Although magnetic data do not show correspondence of anomaly maxima with gravity counterparts, the solution of magnetic and gravity data are obviously related. Comprehensive measurements of density and susceptibility will be required before interpretation of geophysical data can be advanced in this area.

The area west of Mary Ann contains intersecting shear zones and is of geological interest and consideration should be given to further geophysical work there.

<u>Area AR2</u>

As a result of the vertical and horizontal magnetic field surveys over area AR2 by Williams in 1969, a drill target was defined beneath 7000W, 5150N at a depth of 600 feet. A hole subsequently drilled from 7000W, 4800N towards grid north at a depression of 62° intersected quartz magnetite with minor pyrite and very minor chalcopyrite between 816 and 851 feet downhole (approximately 723-755 feet vertical depth below 5190N).

The extension of work in 1971 involved a gradient magnetic survey of traverse 7000W. Although data proved to be noisy, two anomalies could be resolved, as shown by the top set of profiles in Plate 19. The short wavelength anomaly which exceeds 10 gammas/ft originates from a very near-surface source, whereas the broader anomaly is interpreted to be caused by a body at a depth of 270 feet. Smoothed profile 1 yielded this depth and a body 220 feet wide. This width is considerably greater than the quartz magnetite zone intersected by drilling; hence the application of quantitative interpretation to the data must be questioned.

Interpretation of vertical magnetic data obtained by Williams is also shown in Plate 19. Poor curve fits are obtained from both the dyke and sphere solutions particularly in the region between 4000 and 5000N. A summary of the body parameters interpreted from the various forms of data is shown in Table 3, from which it is apparent that the depth estimate varies little regardless of the solution applied or data form used.

Table 3

| INTERPRETATION OF MAGNETIC DATA FROM TRAVERSE 7000W | | | | |
|---|---|---|---|---|
| COMPONENT | BODY | APEX | DEPTH (feet) | DIP |
| Vertical | Thin infinite dyke | 5185N | 250 | $90^{o}$ |
| Horizontal | " | 5170N | 250 | $90^{o}$ |
| Total | " | 5160N | 253 | $90^{o}$ |
| Gradient (1) | Dyke | 5360N | 270 | |
| Gradient (2) | Dyke | 5240N | 230 | |

## Aeromagnetic Ridge - Traverse 9600E

The Aeromagnetic Ridge anomaly as defined by the 1964 detailed aeromagnetic survey (Milsom & Finney, 1965) was first subjected to ground investigations by Williams in 1969. One major traverse surveyed, 9600E, was extended to the south and north in 1971, with vertical and total magnetic field measurements recorded at 100-foot intervals as shown in Plate 20. Additional gravity data were also obtained on this traverse: stations at 100-foot intervals now exist from 5000N to 15500S and the remainder of the traverse has been surveyed with a station interval of 500 feet.

All geophysical data obtained show both regional and local anomalies. In the magnetic data, a regional trend is apparent in the form of increasing magnetic intensity towards the centre of the traverse, a maximum being reached over the Aeromagnetic Ridge. This reflects the change in rock type from relatively non-magnetic granites at either end of the traverse to the more magnetic rock types of the Warramunga Group in the central region. Superimposed on this regional feature are anomalies some of which can be attributed to rock units of known high magnetite content. Such anomalies are those near Lone Star, AR13, and West Peko. Mutual interference of such anomalies and those over the Aeromagnetic Ridge and at 26500S and 32000S make quantitative interpretation extremely difficult. These anomalies probably account for the regional anomaly to a large degree.

The local anomaly at the Aeromagnetic Ridge demands the greatest attention for quantitative interpretation as no geological solution is immediately obvious. Curve matching methods produce considerable ambiguity about the form of the causative source, as shown by Plates 21 and 22. This arises from the problem of separating the Aeromagnetic Ridge anomaly from those designated West Peko and AR13.

The more favoured solution involves a thick dyke-like body which reaches to within 1400 feet of the surface. The jagged appearances of the observed magnetic profiles are interpreted as due to apophyses rising from the main body. A discrepancy exists between the interpreted dip of 30°S for the anomaly source and the near verticality of the beds indicated by geological mapping in this locality. The two could be reconciled, however, if the direction of magnetization of the body were near vertical, implying the presence of remanent magnetization.

Interpretations based on spherical models are also shown in Plates 21 and 22, which in general suggest deeper sources for the anomaly. The acceptability of such a model is extremely doubtful because the Aeromagnetic Ridge anomaly is elongated, although culminations do occur along its length, in particular where traverse 9600E intersects it.

Gravity data show peak values in the region 20000S-25000S, with lows at either end of the traverse (Plate 23). This again basically reflects the enclosure of Warramunga Group rocks between two granite masses of lower density.

Although local gravity anomalies are apparent such as at 25000S, 21000S, 6000N and 13000N it is impossible to determine their source without more extensive information. Topographic and weathering effects could be of major significance, as could the presence of dense magnetite-rich rock units. Distinctive anomalies do not appear to complement magnetic features at the Aeromagnetic Ridge or at West Peko.

Comet Prospect

The Comet prospect was also surveyed by Williams in 1969. Taube (1968) gives details of two diamond drill-holes which intersected ironstone with low gold values. The ironstone body crops out at 3850S/12700E and has a plunge of $70^{o}$N.

In 1971 magnetic gradient readings were recorded from 4600S to 0, and gravity readings from 1700S to 2000N on Traverse 12700E, to which Williams' results were tied.

Because stations occupied were too widely spaced, the magnetic gradient profile (Plate 24) was not amenable to quantitative interpretation. A high was recorded however over the ironstone outcrop. A gravity high of 1 mgal (Plate 24) also occurs over this outcrop.

Area AR6

Earlier work by Williams defined an anomaly which was attributed to a fairly deep body. Gradient magnetic data recorded in 1971 did not produce a noticeable anomaly over this feature.

Area AR10

Although data acquired by Williams over AR10 proved very difficult to interpret, it appears that an ironstone body is present within 400 feet from surface. Magnetic gradient data obtained in 1971 did not reveal an anomalous response, so the body is not intensely magnetized.

## 7. CONCLUSIONS AND RECOMMENDATIONS

Interpretation of supplementary magnetic data at C6 produced results very similar to those obtained by Haigh. The magnetic gradient and gravity work indicate that the drilled ironstone body plunges steeply to the north-northeast. If any further drilling of this body is required, DDH20 as specified in Table 4 will furnish the optimum test of the geophysical anomaly defined. Six wagon drill-holes (WDH1-6) are recommended for investigation of an area of positive magnetic gradient outlined at the western end of the gravity ridge.

It appears that in this area magnetic and gravity anomalies are directly related to magnetite mineralization included in a sheared prophyry unit. Consideration should be given to extending gravity and magnetic coverage to the east and northwest for both economic and regional geological considerations. To maximize the value of geophysical data so far acquired, all drill core should be logged for density and susceptibility.

Data acquired at C8 has defined more precisely an area for a drill hole test; however, additional ground control is recommended to define the target location as clearly as possible.

Reinterpretation of the C11 anomaly indicates satisfactory correlation between the magnetic interpretations and the drilled body. Gravity data in particular indicate the presence of more ironstone at a greater depth. To test this hypothesis, DDH21, as specified, is recommended.

Investigation of the C12 magnetic anomaly had produced little information additional to that obtained by Haigh. As gravity data did not reveal a significant anomaly, it is unlikely that a large ironstone body exists and accordingly no further work is recommended.

The lack of correlation between magnetic and gravity anomalies at Mary Ann is quite outstanding. The absence of a gravity anomaly to support the magnetic anomaly necessarily downgrades the potential significance of the magnetic feature. Accordingly, both forms of anomaly type as recorded probably relate to regional stratigraphic features rather than indicating the presence of highly magnetic and dense ironstone bodies. Two diamond drill holes are recommended primarily as stratigraphic tests, the first to yield information on the most significant magnetic feature, namely the anomaly culmination 1 km west of Mary Ann, and the second to establish the significance of the gravity anomaly centred at 500N on traverse 8000E. Drill hole specifications for the second test would obviously be controlled to some extent by results from the first hole and are thus not given here.

The extension of work on Traverse 9600E was primarily aimed at producing a better understanding of the Aeromagnetic Ridge anomaly. It is doubtful whether this objective has been realized other than to suggest that the most probable cause of the anomaly is a broad geological unit which contains disseminated magnetite. Interference from the adjacent AR13 and West Peko anomalies makes quantitative interpretation highly suspect.

Table 4

| AREA | Drill Hole Number | Target Location | Target Depth | Collar Position | Bearing | Depression | Target Position Down Hole | Proposed Drill Hole Length |
|---|---|---|---|---|---|---|---|---|
| C6 | DDH 20 | 1250W/6240N | 800 ft | 1250W/6700N | Grid S | $60^{\circ}$ | 930 ft | 1200 ft |
| C6 | WDH 1 | 1800W/5900N | 100 ft | 1800W/5900N | | $90^{\circ}$ | 100 | 200 |
| | WDH 2 | 1800W/6000N | 80 ft | 1800W/6000N | | $90^{\circ}$ | 80 | 200 |
| | WDH 3 | 1800W/6100N | 100 ft | 1800W/6100N | | $90^{\circ}$ | 100 | 200 |
| | WDH 4 | 1900W/5900N | 80 ft | 1900W/5900N | | $90^{\circ}$ | 80 | 200 |
| | WDH 5 | 1900W/6000N | 50 ft | 1900W/6000N | | $90^{\circ}$ | 50 | 200 |
| | WDH 6 | 2000W/5900N | 60 ft | 2000W/5900N | | $90^{\circ}$ | 60 | 200 |
| C11 | DDH 21 | 100E/1275N* | 390 ft | 100E/1500N | Grid S | $60^{\circ}$ | 450 ft | 600 ft |
| MARY ANN | DDH 22 | 8000E/870S | 1100 ft | 8000E/1500S | Grid N | $60^{\circ}$ | 1270 ft | 1300 ft |
| | DDH 23 | 8000E/600N | 800 ft | To be determined from drilling results of DDH 2 | | | | |
| 9600E | DDH 24 | 9600E/2125S | 4800 ft | 9600E/3000S | Grid N | $80^{\circ}$ | 4870 ft | 5200 ft |

* Requirement to drill along 100E determined by the known configuration of ironstone lode

It is difficult to justify a drill hole test of the anomaly for an economic target based on geophysical data alone. Accordingly DDH24 is suggested like the counterparts at Mary Ann primarily as a stratigraphic test which will yield data on a major ironstone body if one is present.

Insufficient information was produced by the single traverse 9600E to develop an acceptable model of relationship of Warramunga Group rocks to enclosing and possibly underlying granites. Additional regional traverses are thereby recommended, with particular reference to gravity work.

In general it was found that gradient magnetic measurements yield useful additional information for interpretation. Noise problems produce the most serious limitation to such work. For future surveys it is recommended that a closer station spacing be used for gradient studies than that conventionally used for magnetic intensity work.

Much greater use of basic rock property measurements is required to assist future data interpretation. Regional studies in particular will demand this.

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## APPENDIX

### Aeromagnetic Ridge - Northern extension of traverse 9600E

As a result of the 1971 survey work, it was decided to expand magnetic survey coverage northwards from the end of traverse 9600E in order to define accurately an anomaly located near 40000N. This was done by the author in 1972, vertical and total magnetic field readings being made from which contours of total magnetic field are shown in Plate A1. In addition to this, gravity readings were obtained along traverse 9200E, as shown in Plate A3.

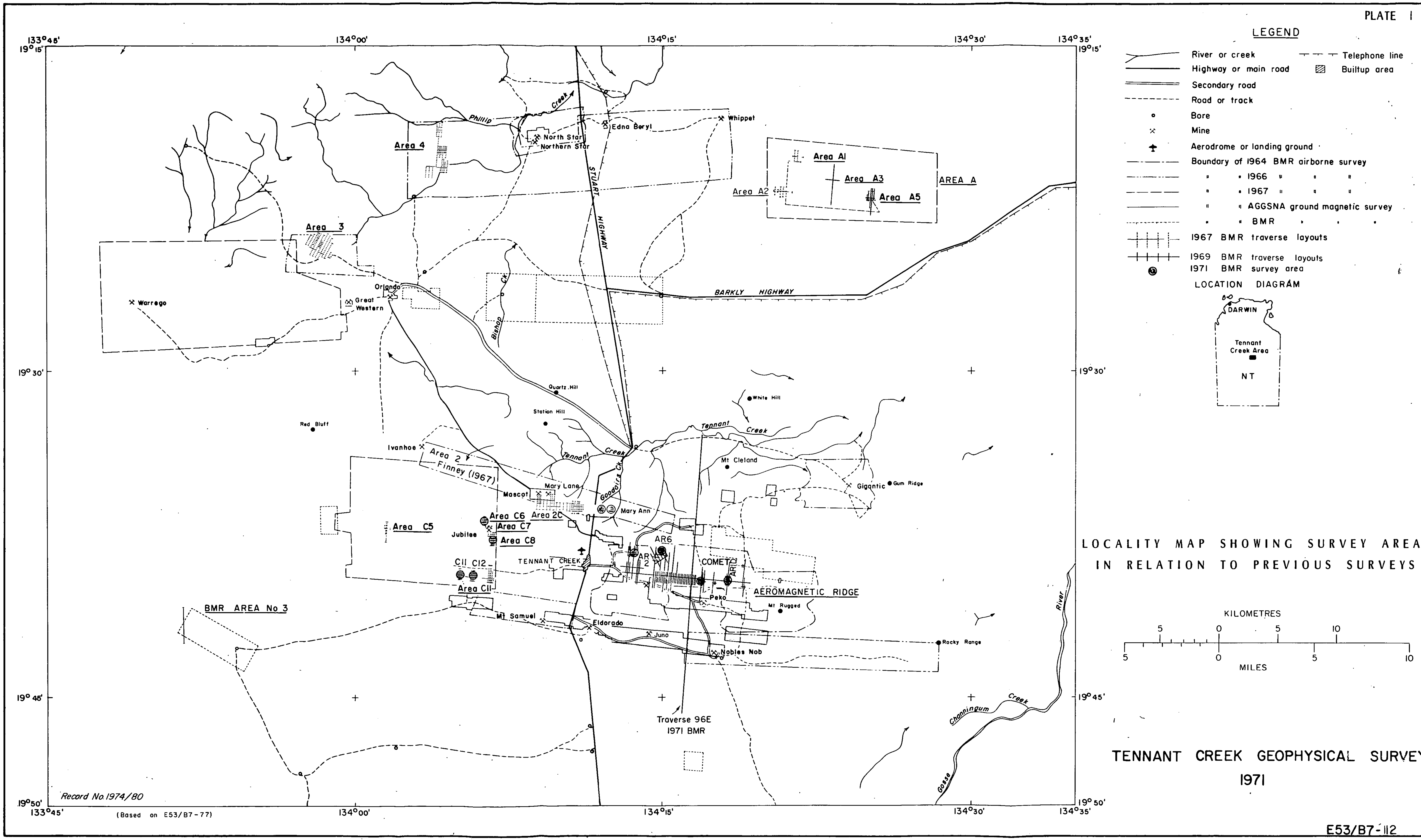
The geology in this locality is mostly obscured by alluvium. However, it is believed that the area is underlain by Warramunga Group sediments, a contact between which and granite occurs approximately 1.5 km north of 40000N.

From the contours displayed in Plate A1 it is apparent that the magnetic anomaly is elongated in an east-west direction centred about 9200E/40300N. The strike extent of the anomaly does not appear to vb bvry great and neither a dyke of infinite strike extent nor a sphere is likely to provide a model which closely approximates the shape of the causative body, although the former would appear to be the better choice. The variation in body parameters obtained by interpretation using curve matching techniques for the principal profile are shown in Table 1A, and typical curve fits are shown in Plate A2.

Plate A3 summarizes various body shapes which can accommodate the magnetic data recorded in terms of curve fitting. None of the hypothetical bodies shown is likely to generate a gravity anomaly in excess of 0.2 milligals at 40000N, even allowing for a density contrast of 0.5 g/cm$^3$. Thus the gravity survey cannot be expected to support the interpretation of the magnetic data directly. The absence of any short wavelength gravity anomaly near 40000N does, however, indicate that no nonmagnetic ironstone body occurs near surface at this locality. Accordingly the drilling recommendation indicated in Plate A3 is designed to test for a deep target of stratigraphic significance.

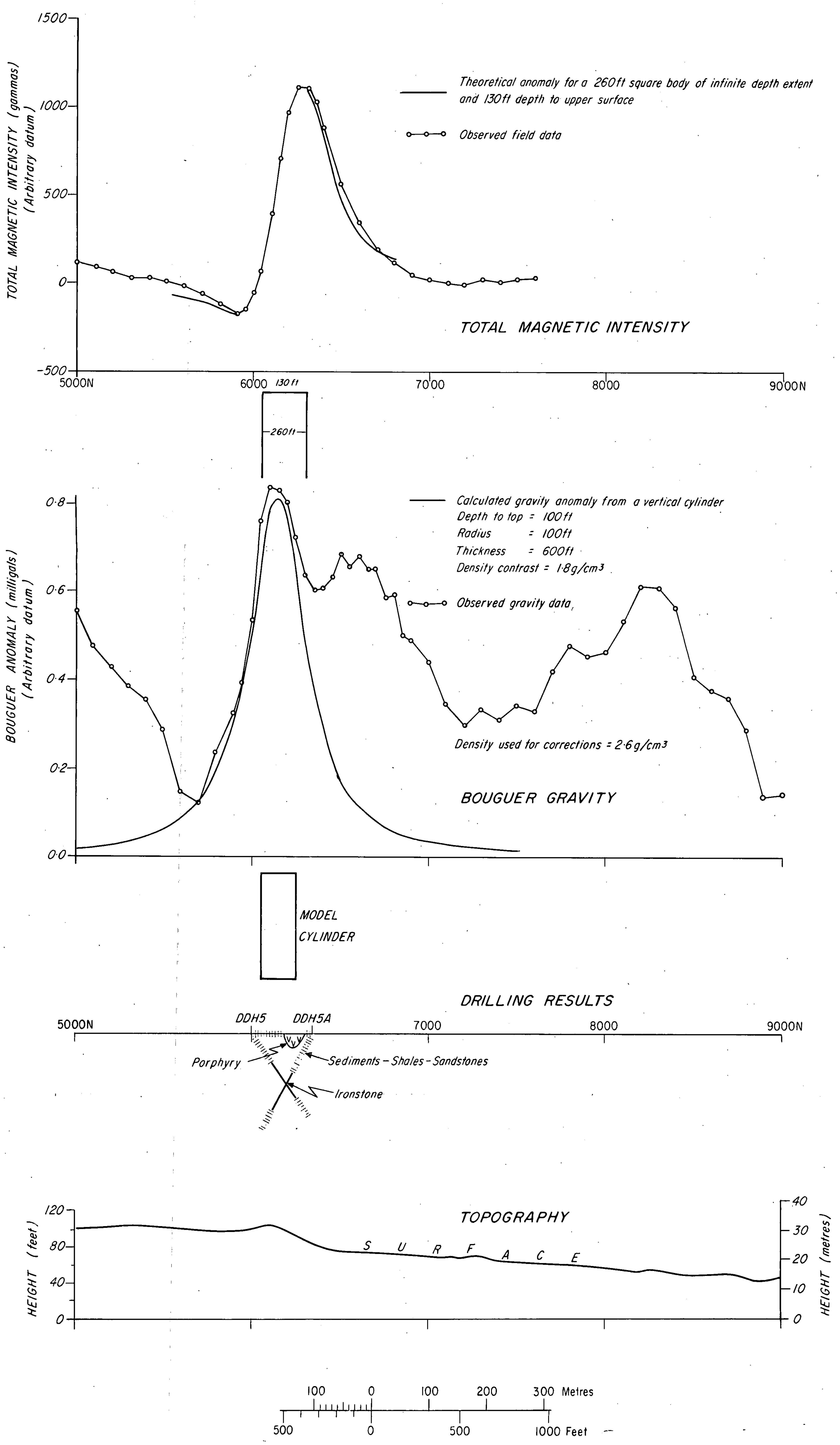
TABLE 1A

| INTERPRETATION OF MAGNETIC DATA FROM TRAVERSE 9200E | | | | | | |
|---|---|---|---|---|---|---|
| Component | Body | Apex (Dyke)<br>Centre (Sphere) | Depth (ft) | Dip | Thickness ) (Dyke) (ft) ) Radius (Sphere) | Susceptibility c.g.s. units |
| Vertical | Dyke | 40020N | 330 | $100^{\circ}$ | 490 | 0.003 |
| " | " | 40025N | 320 | $100^{\circ}$ | 620 | 0.002 |
| " | Sphere | 40000N | 800 | - | 160 | 0.100 |
| " | " | " | " | - | 330 | 0.010 |
| " | " | " | " | - | 710 | 0.001 |
| Total | Dyke | 40000N | 330 | $100^{\circ}$ | 490 | 0.002 |
| " | Sphere | 40000N | 760 | - | 150 | 0.100 |
| " | " | " | " | - | 320 | 0.010 |
| " | " | " | " | - | 690 | 0.001 |




LOCALITY MAP SHOWING SURVEY AREAS IN RELATION TO PREVIOUS SURVEYS

TENNANT CREEK GEOPHYSICAL SURVEY 1971




# TENNANT CREEK AREA C 6
## GEOPHYSICAL DRILLING RESULTS, AND TOPOGRAPHY
## TRAVERSE 1200 W

Record No. 1974/80

E53/B7-133

PLATE 2

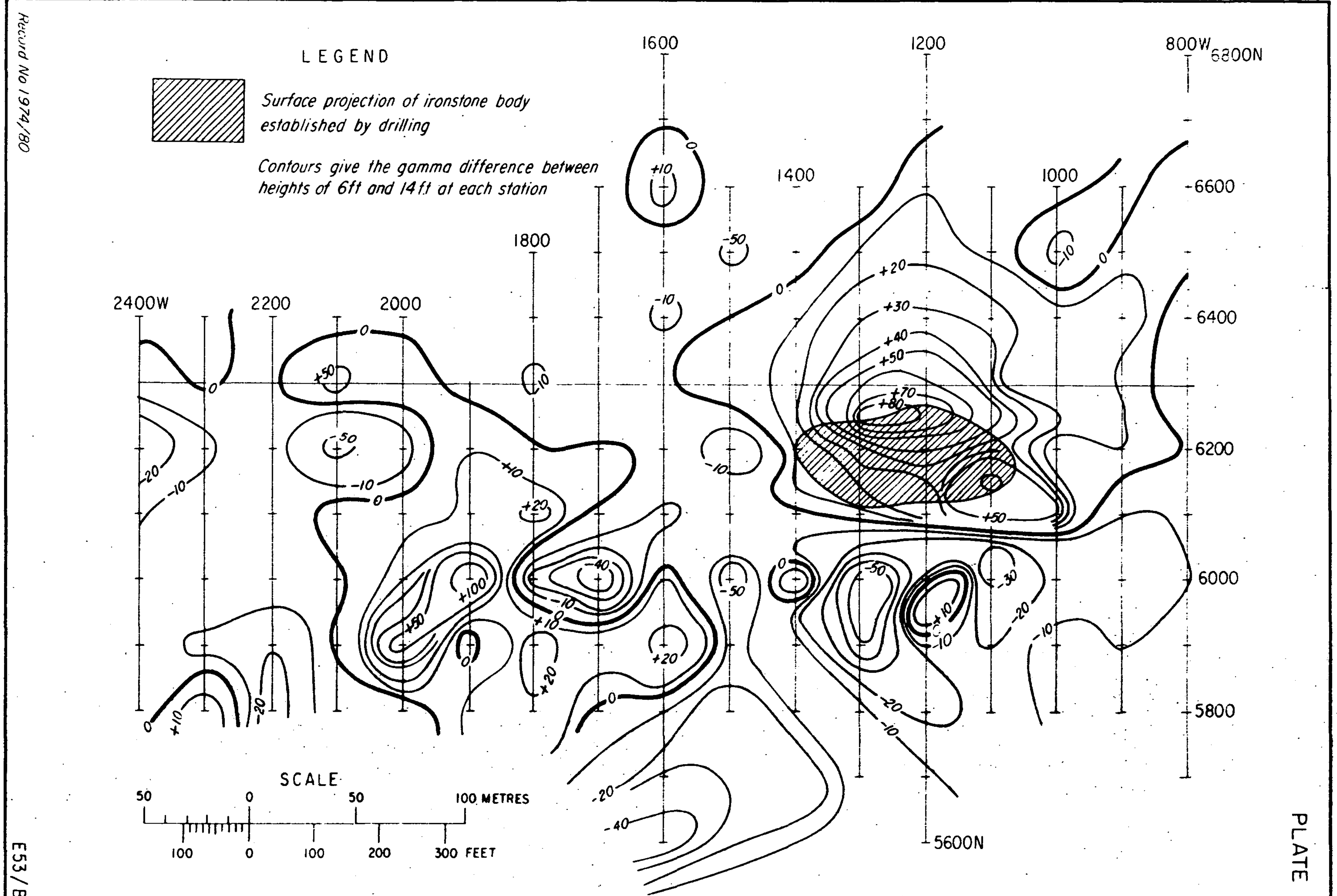


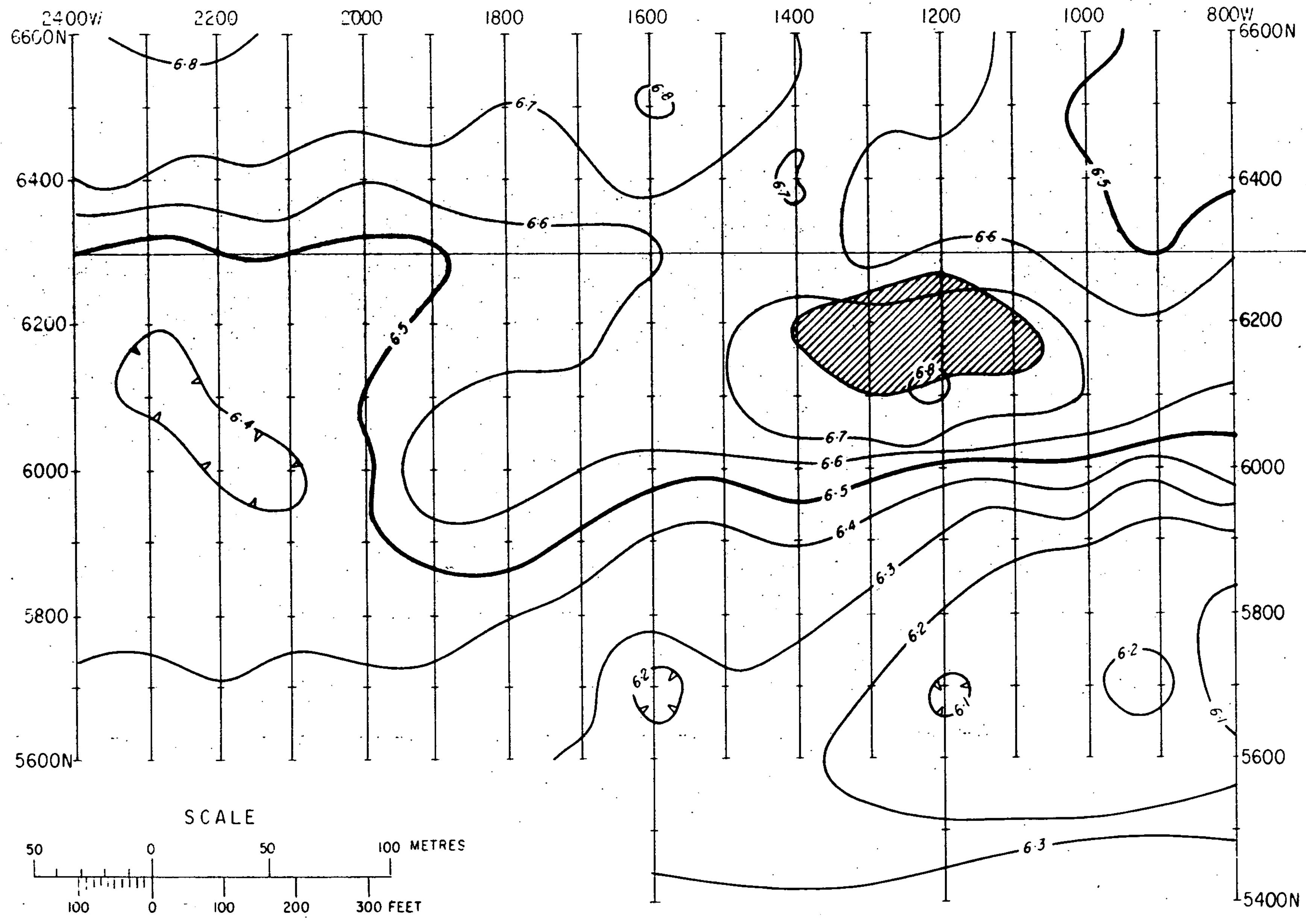





PLATE 3

TENNANT CREEK AREA C 6

VERTICAL GRADIENT OF THE TOTAL MAGNETIC FIELD




Density assumed for corrections = 2·6 g/cm³

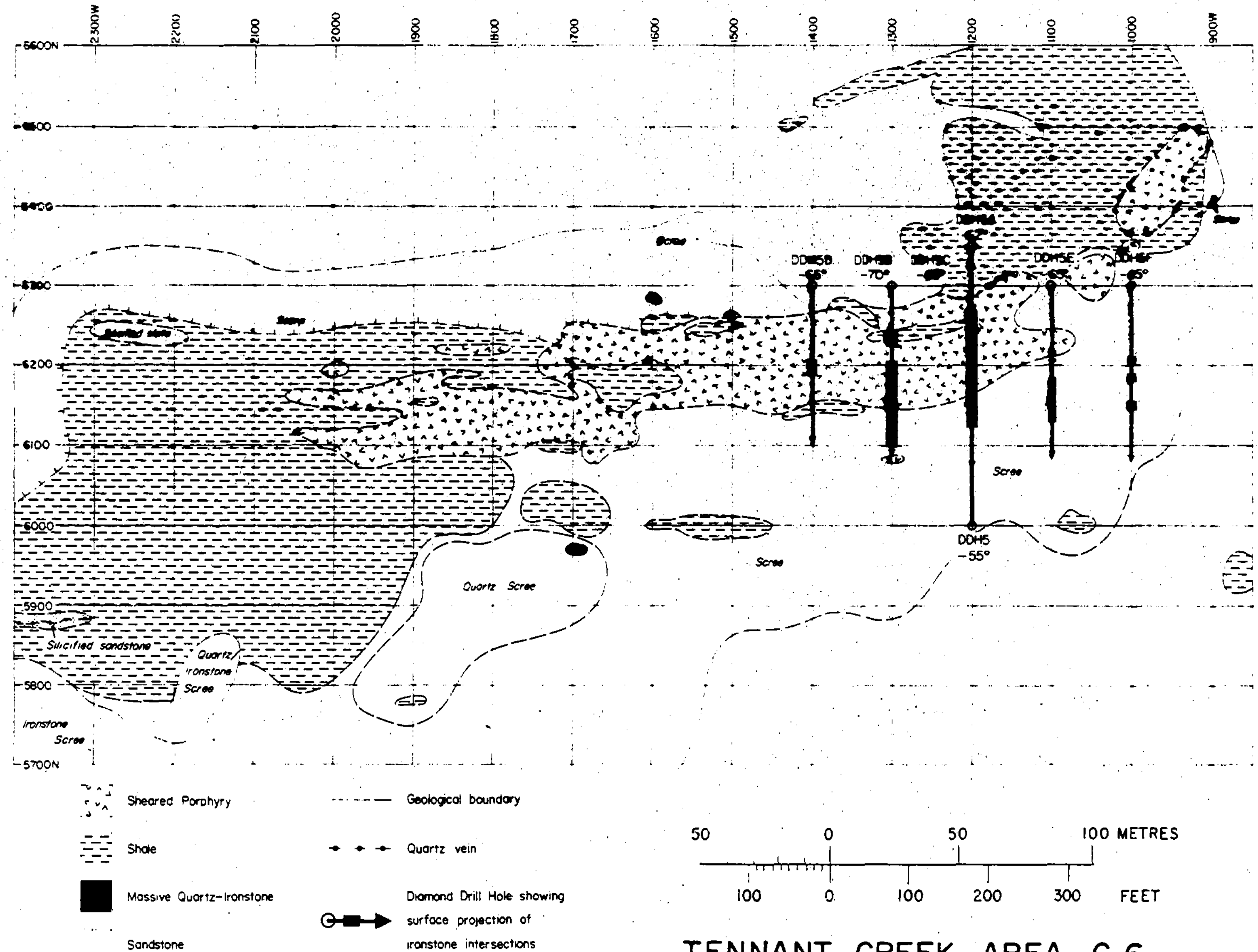
Surface projection of ironstone body established by drilling

## TENNANT CREEK AREA C 6
## BOUGUER GRAVITY CONTOURS

PLATE 4

E53/B7-157A

Record No. 1974/80



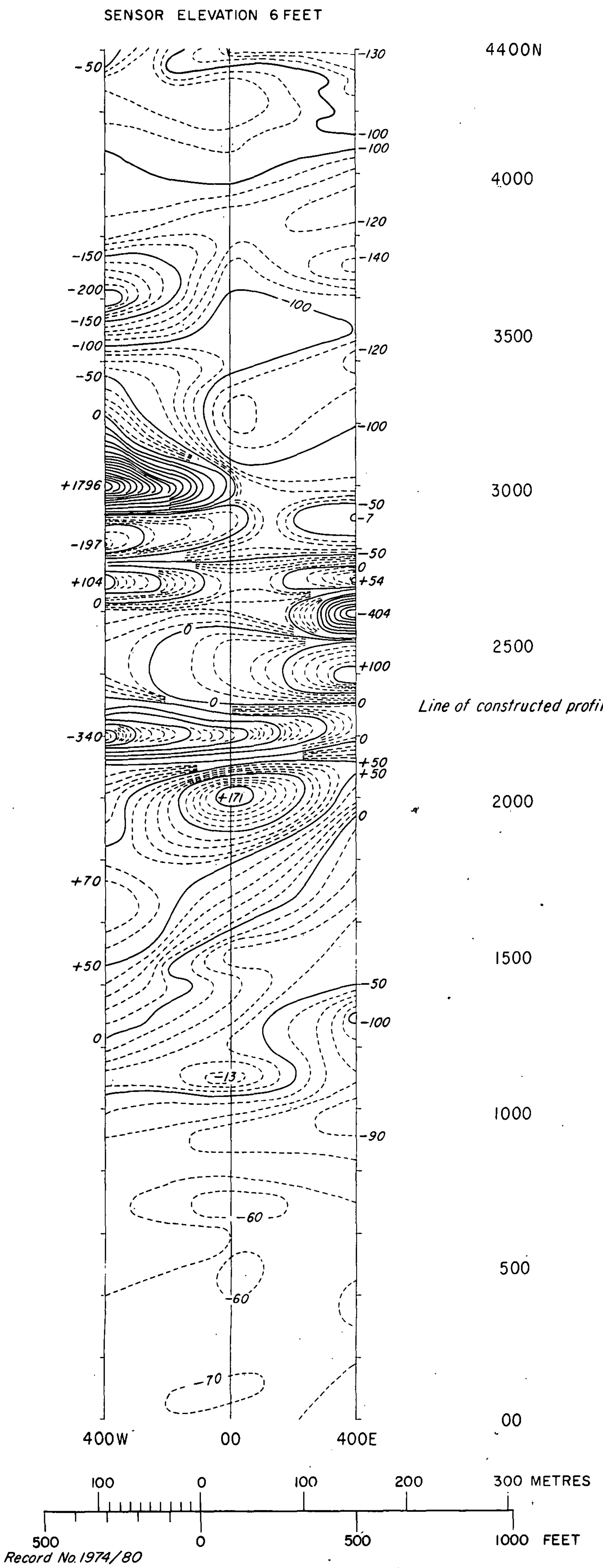

Geology after Willis & Daly, 1972

# TENNANT CREEK AREA C 6
# GEOLOGY AND DRILLING RESULTS

E53/B7-159A

PLATE 5

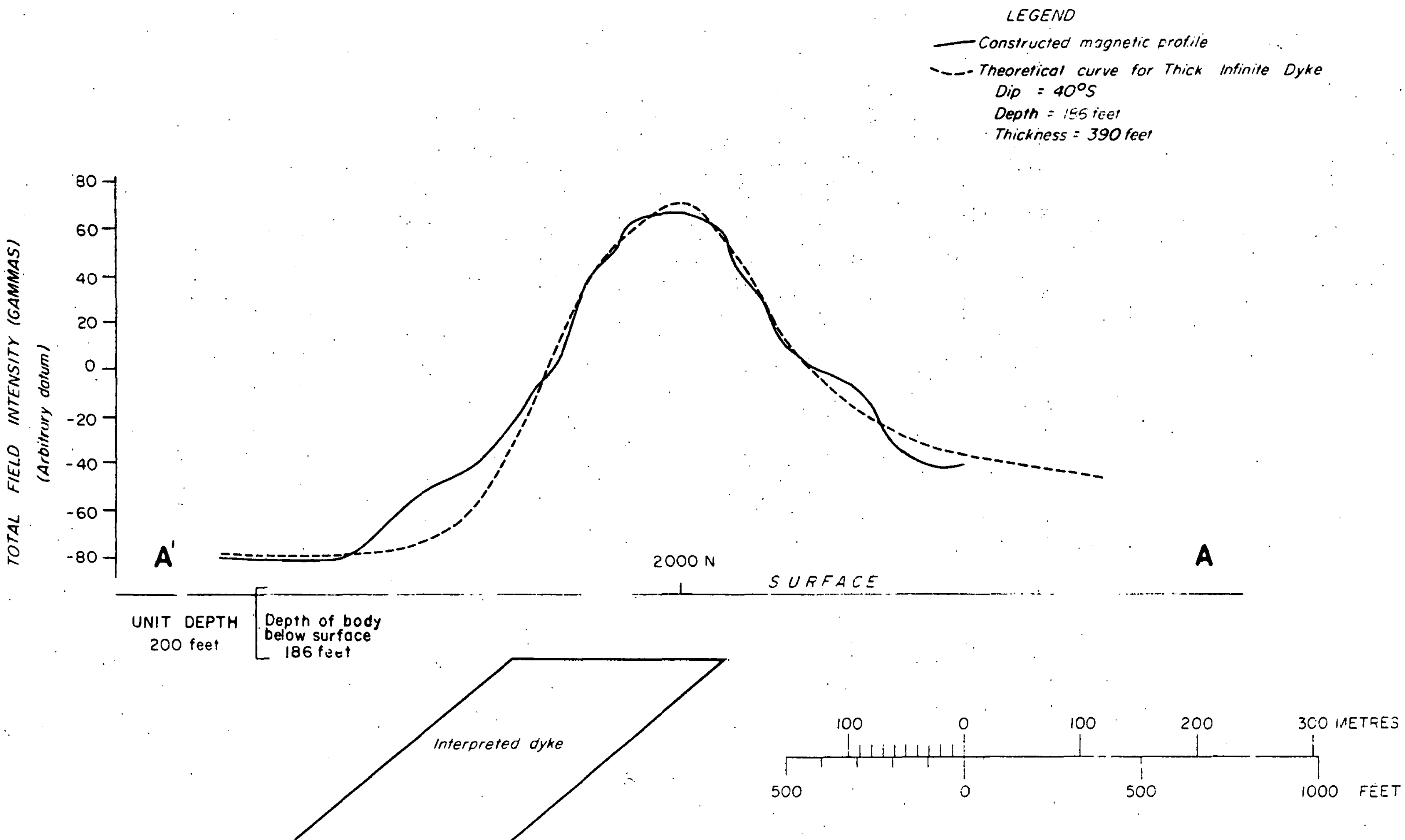
PLATE 6




# TENNANT CREEK AREA C 8
# TOTAL MAGNETIC INTENSITY CONTOURS

Record No.1974/80

E 53/B7-147



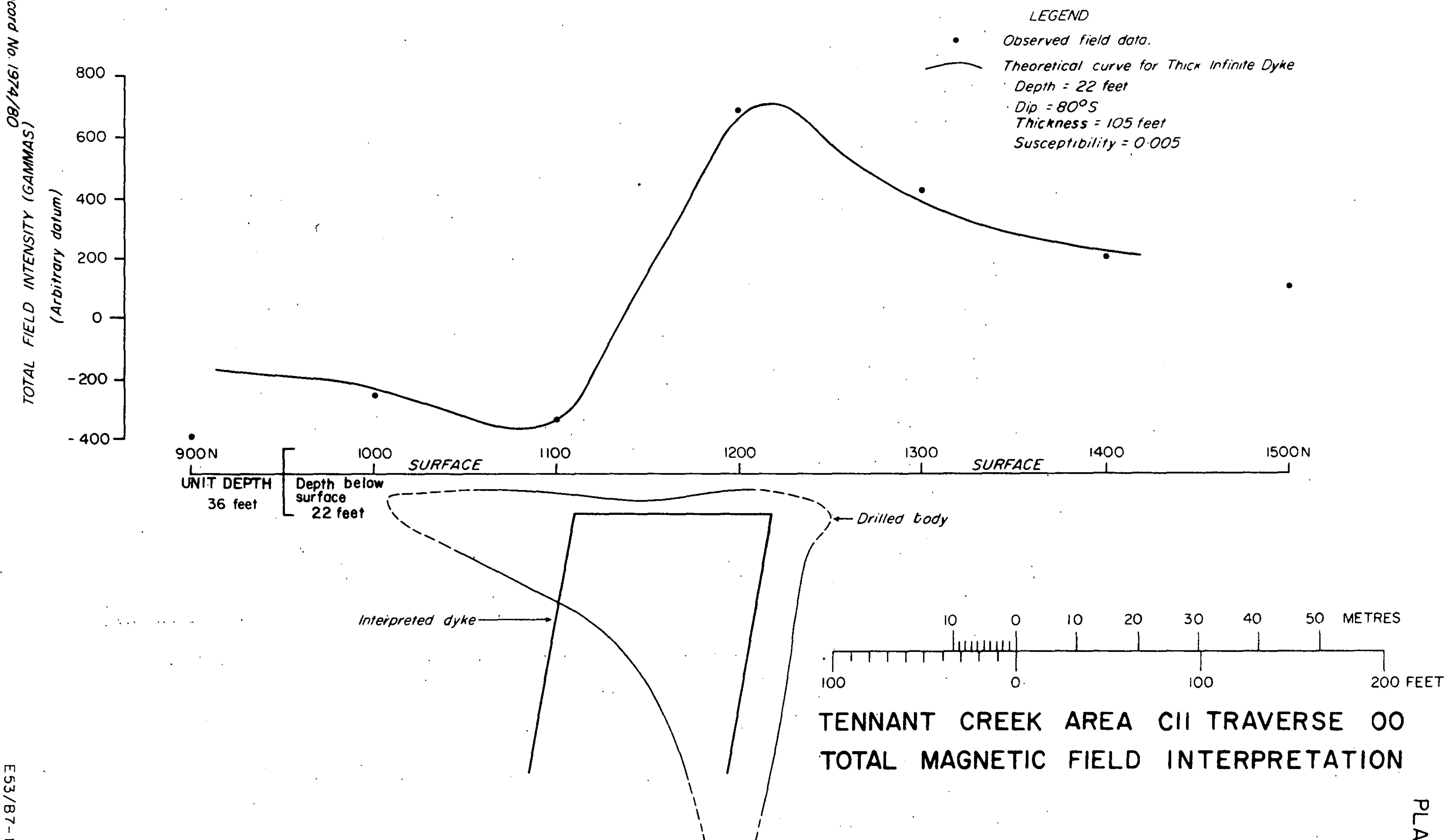

TENNANT CREEK AREA C 8

SECTION A'–A

MAGNETIC INTERPRETATION

PLATE 7

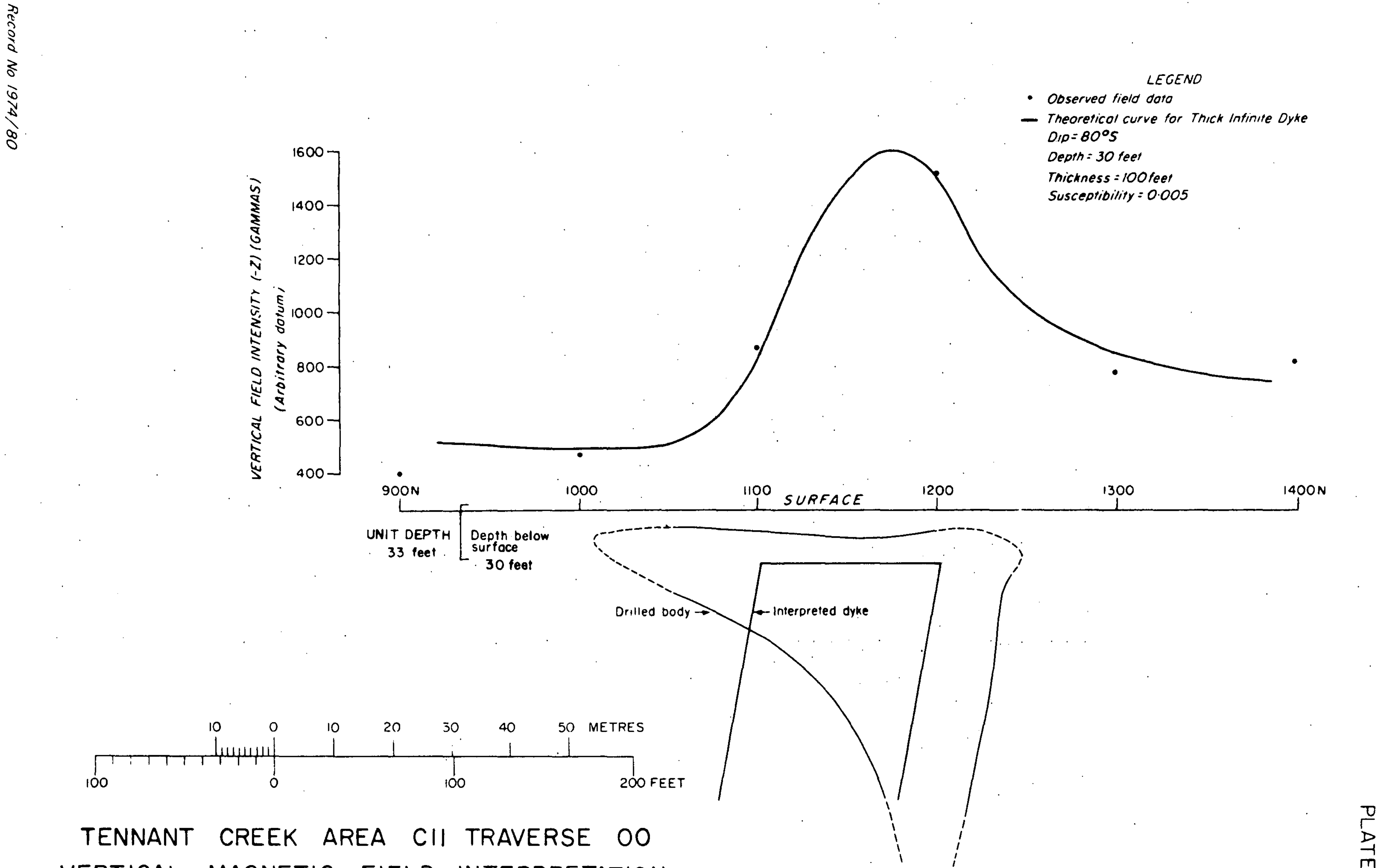
E53/B7-134A




TENNANT CREEK AREA C11 TRAVERSE 00
TOTAL MAGNETIC FIELD INTERPRETATION

PLATE 8

E53/B7-139A

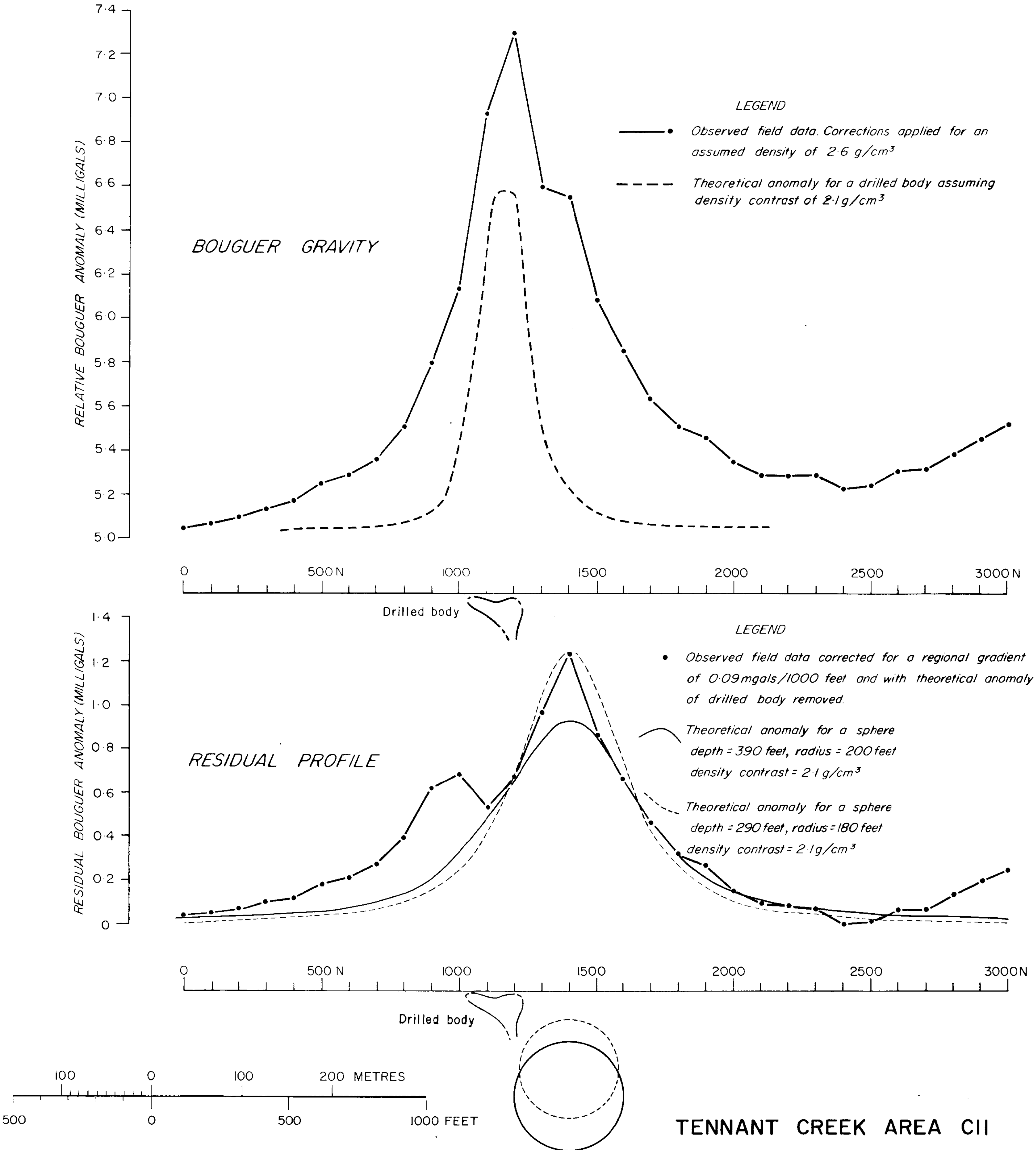



TENNANT CREEK AREA C11 TRAVERSE 00
VERTICAL MAGNETIC FIELD INTERPRETATION

PLATE 9

Record No 1974/80

PLATE 10



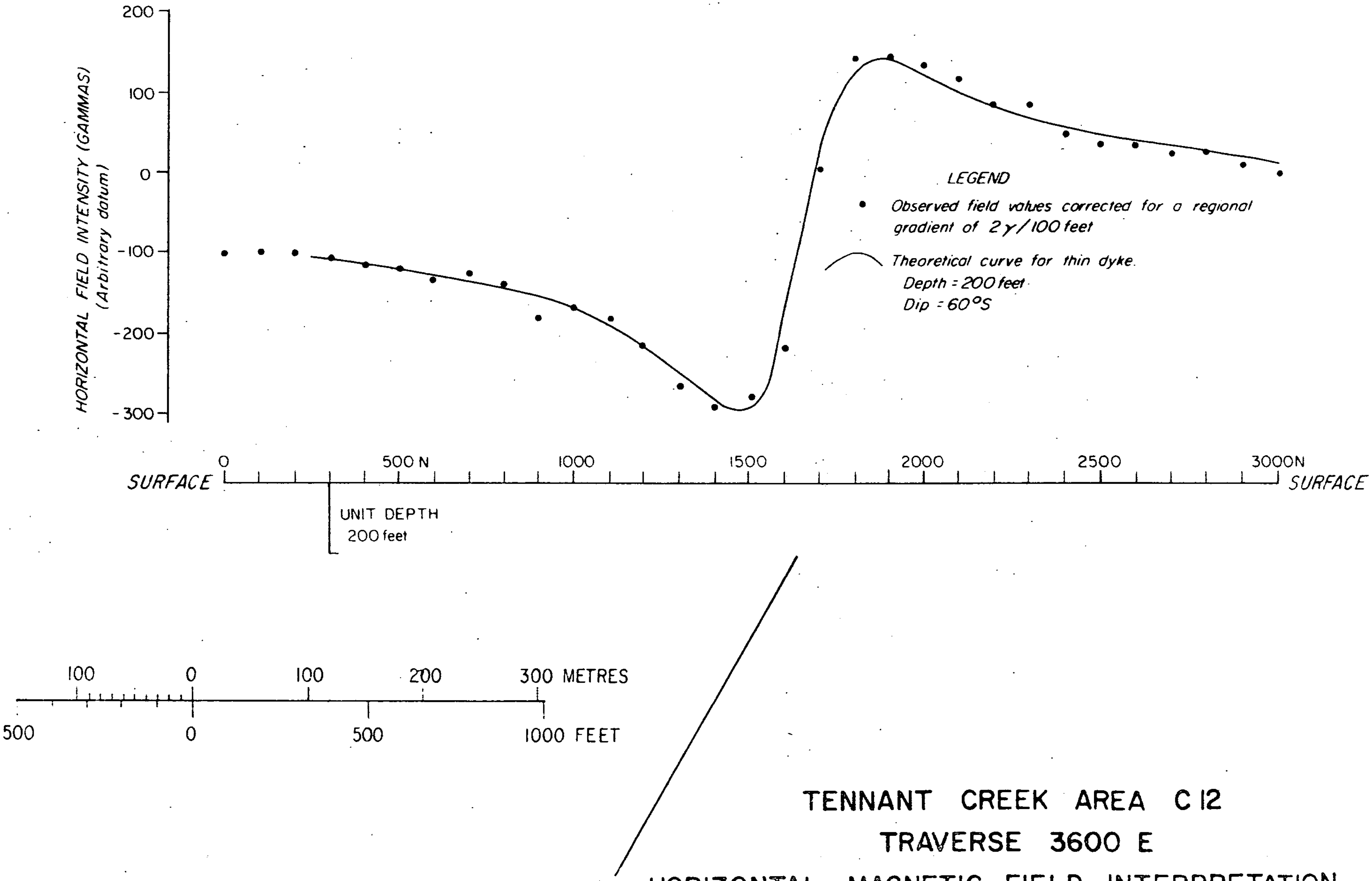

E53/B7-137

TENNANT CREEK AREA C11

TRAVERSE 00

GRAVITY PROFILES AND INTERPRETATION

Record No. 1974/80

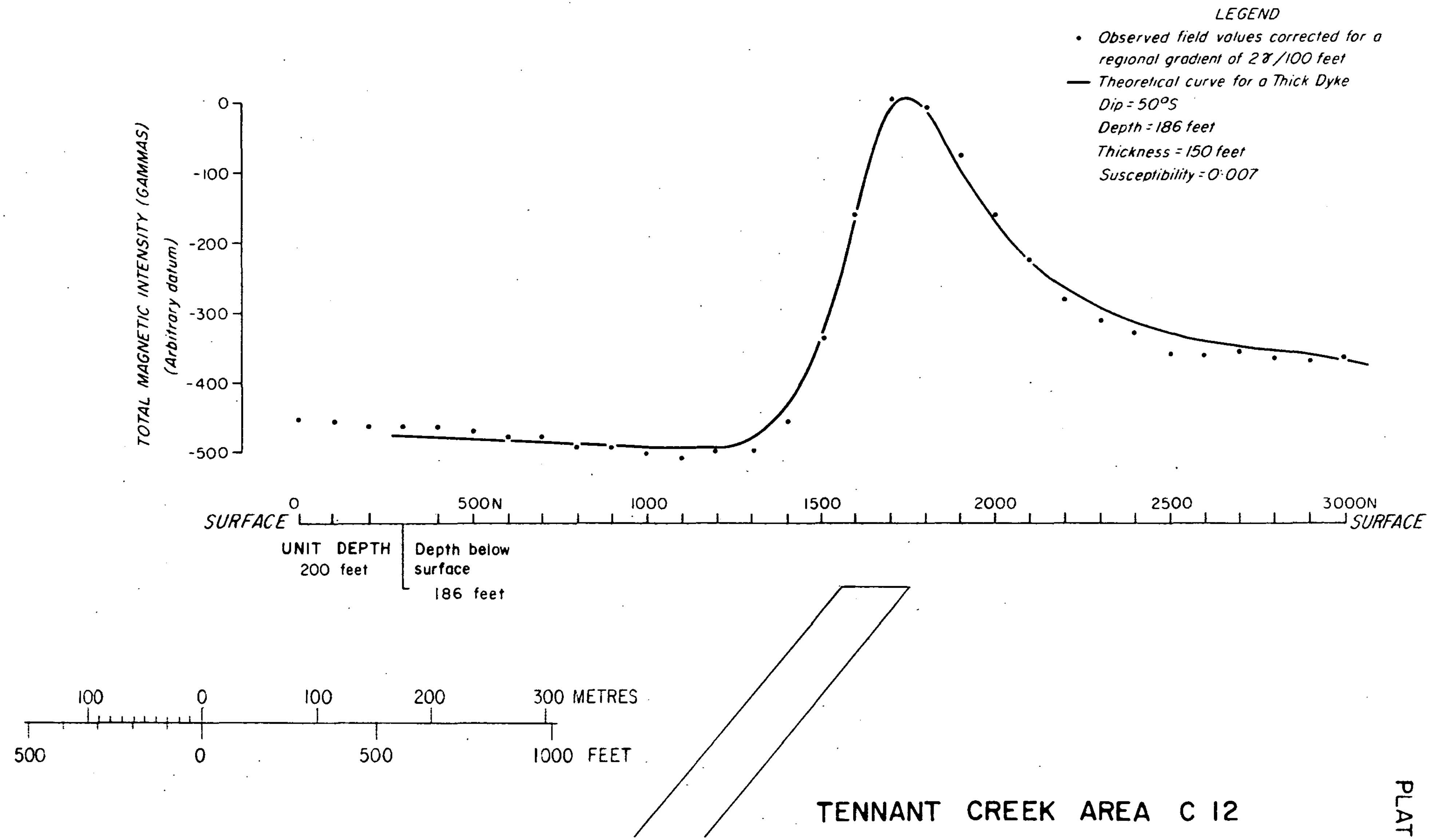



E53/B7-141A

TENNANT CREEK AREA C12
TRAVERSE 3600 E
HORIZONTAL MAGNETIC FIELD INTERPRETATION

PLATE 11

Record No.1974/80



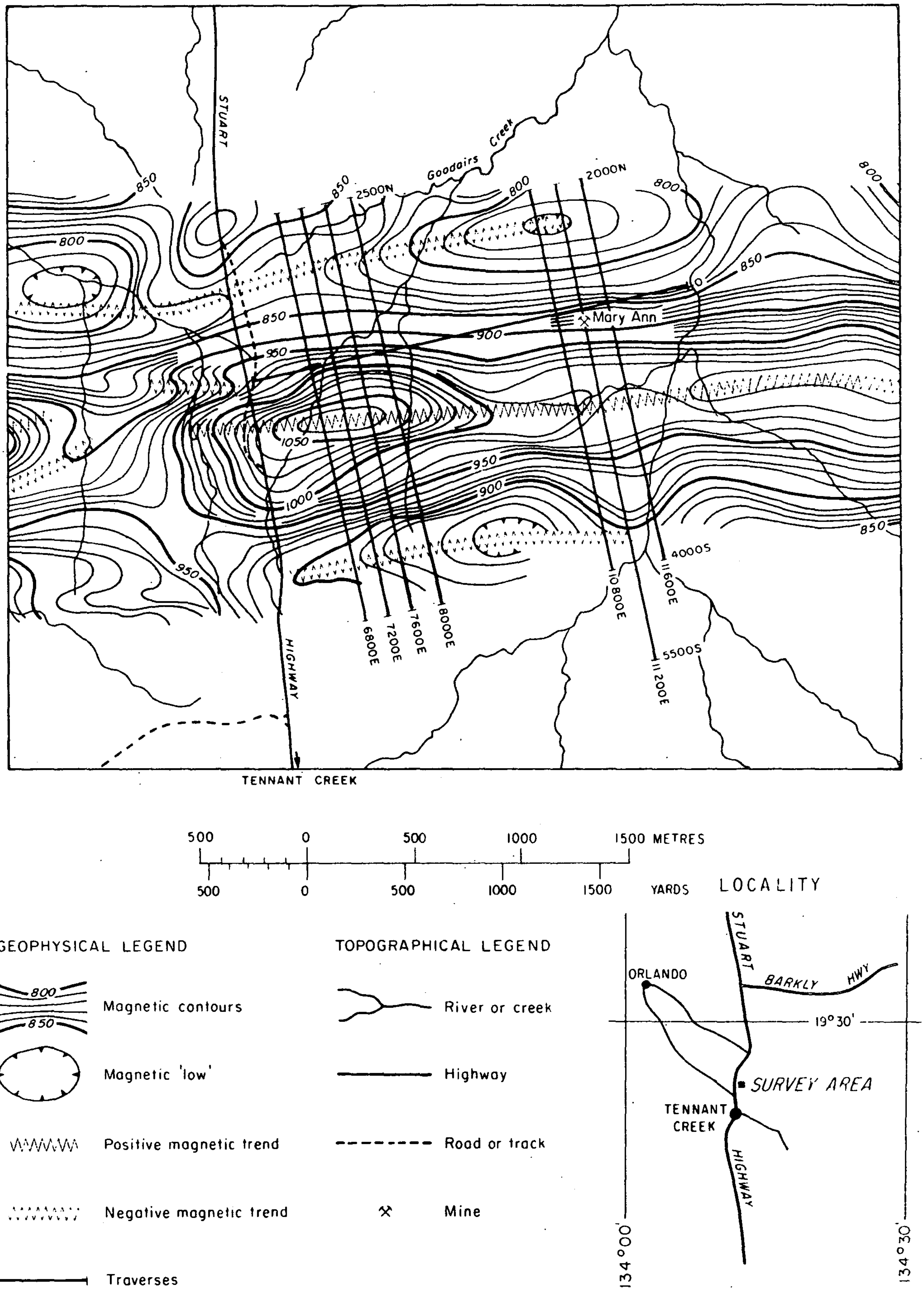

TENNANT CREEK AREA C 12

TRAVERSE 3600 E

TOTAL MAGNETIC FIELD INTERPRETATION

PLATE 12

E53/B7-144A




GEOPHYSICAL LEGEND

- Magnetic contours (800, 850)
- Magnetic 'low'
- Positive magnetic trend
- Negative magnetic trend
- Traverses

TOPOGRAPHICAL LEGEND

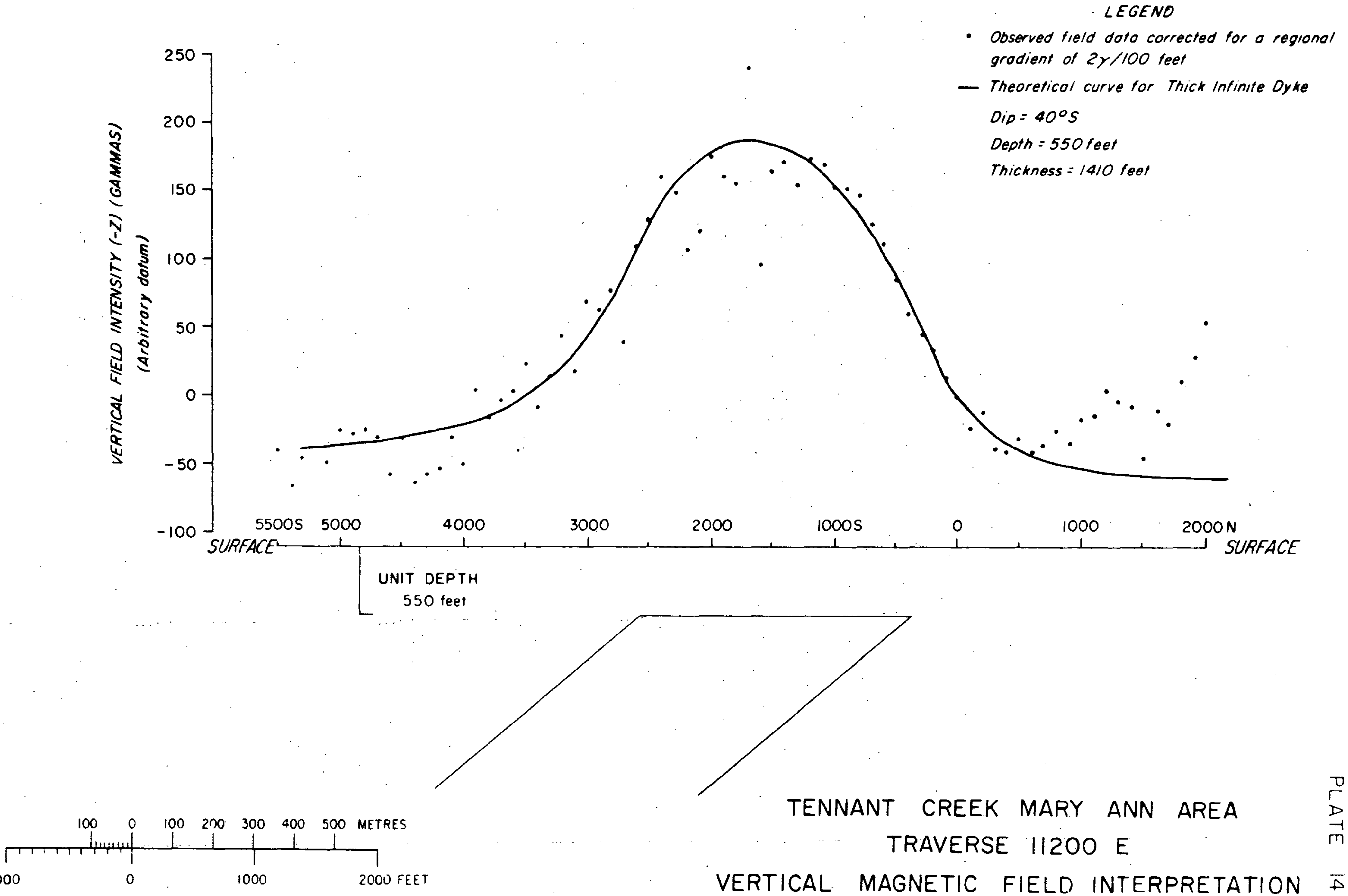
- River or creek
- Highway
- Road or track
- Mine

# MARY ANN AREA
# LOCALITY MAP, TRAVERSE PLAN AND AEROMAGNETIC CONTOURS

*Record No 1974/80*
(BASED ON PART OF E53/B1-37)

E53/B7-158A

Record No. 1974/80



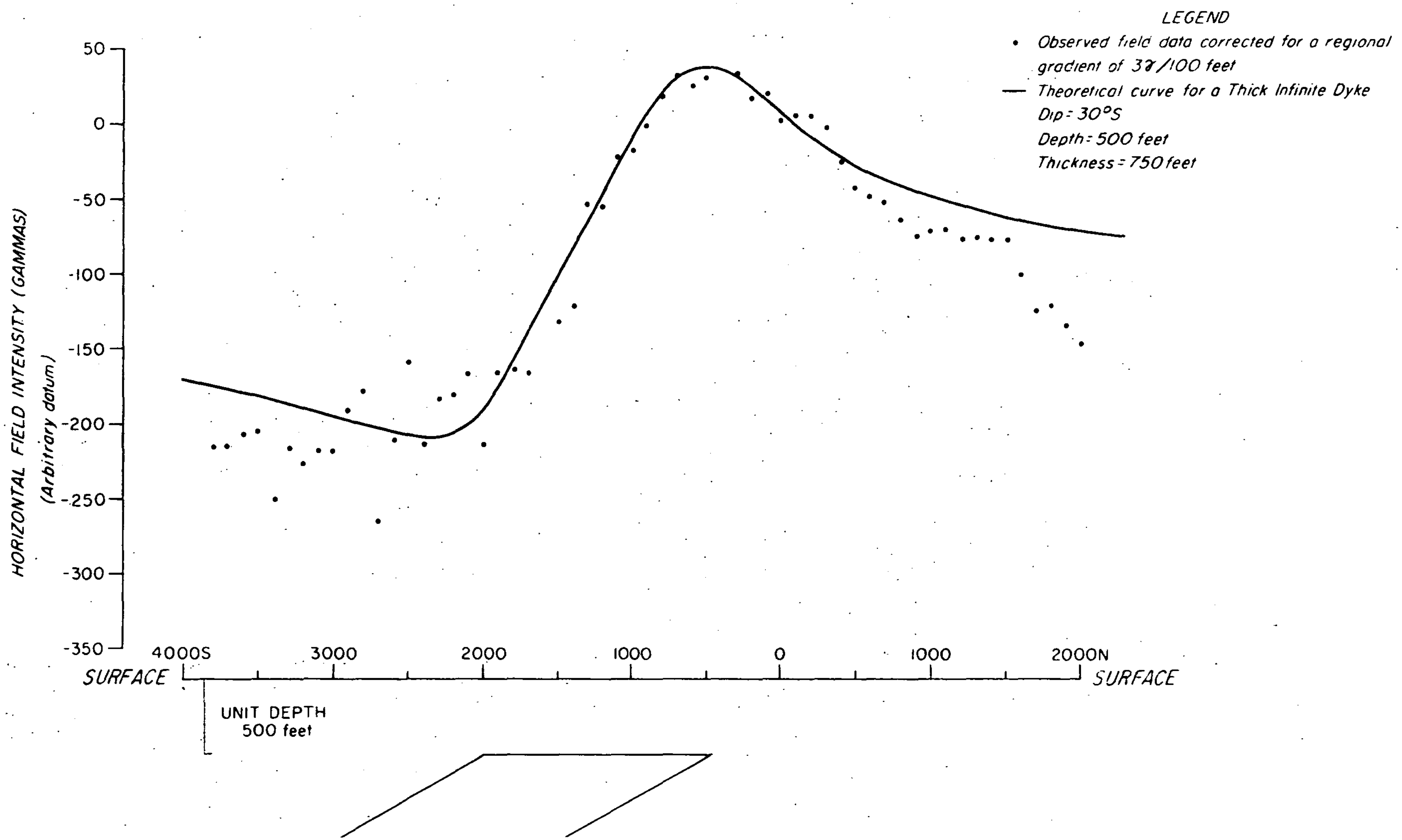

E53/B7-135A

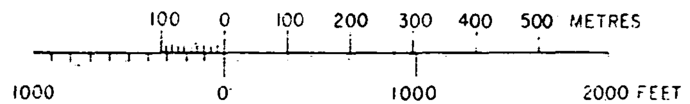
TENNANT CREEK MARY ANN AREA

TRAVERSE 11200 E

VERTICAL MAGNETIC FIELD INTERPRETATION

PLATE 14



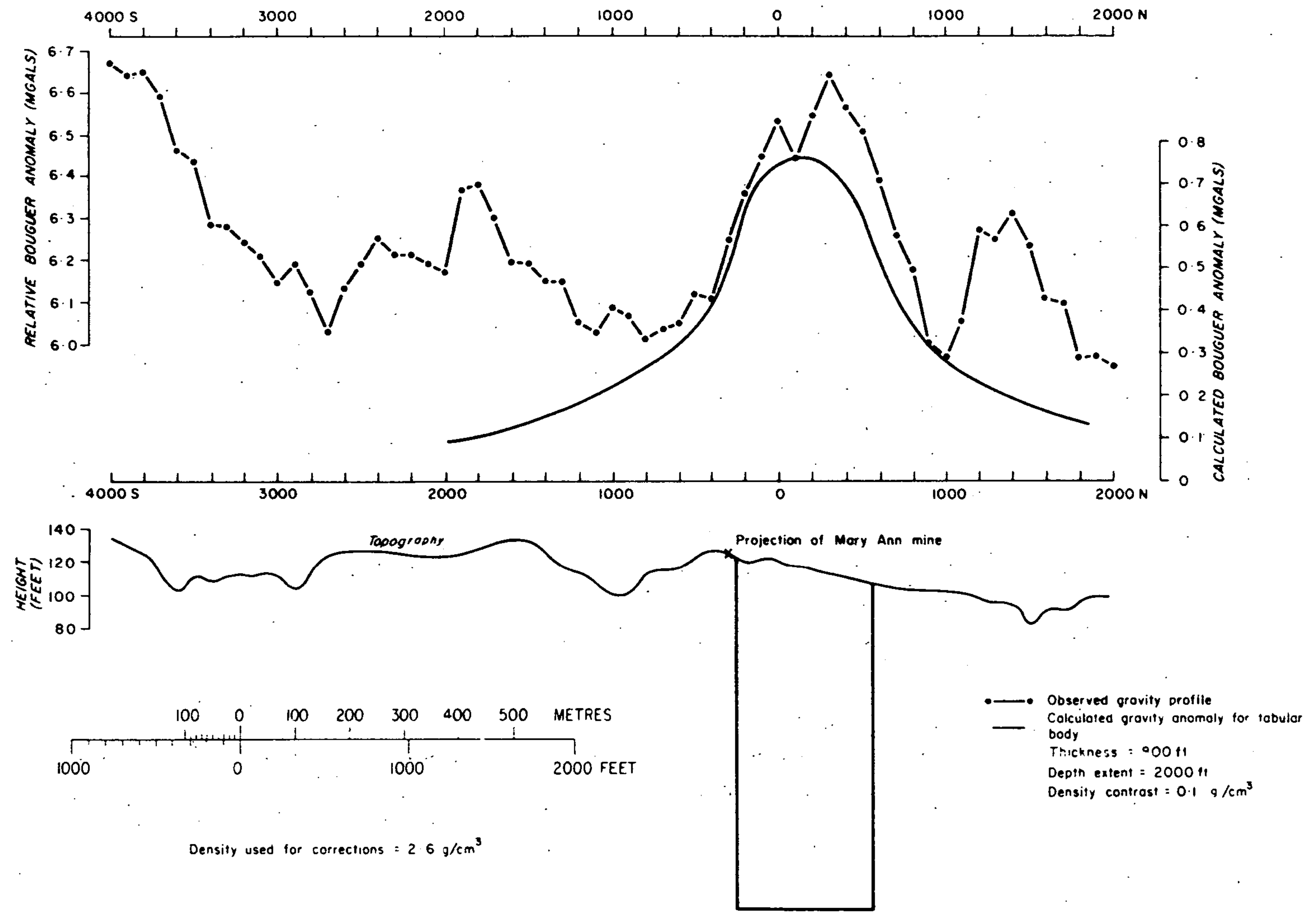




# TENNANT CREEK MARY ANN AREA
## TRAVERSE 11200 E
## HORIZONTAL MAGNETIC FIELD INTERPRETATION

PLATE 15

E53/B7-138A

Record No 1974/80



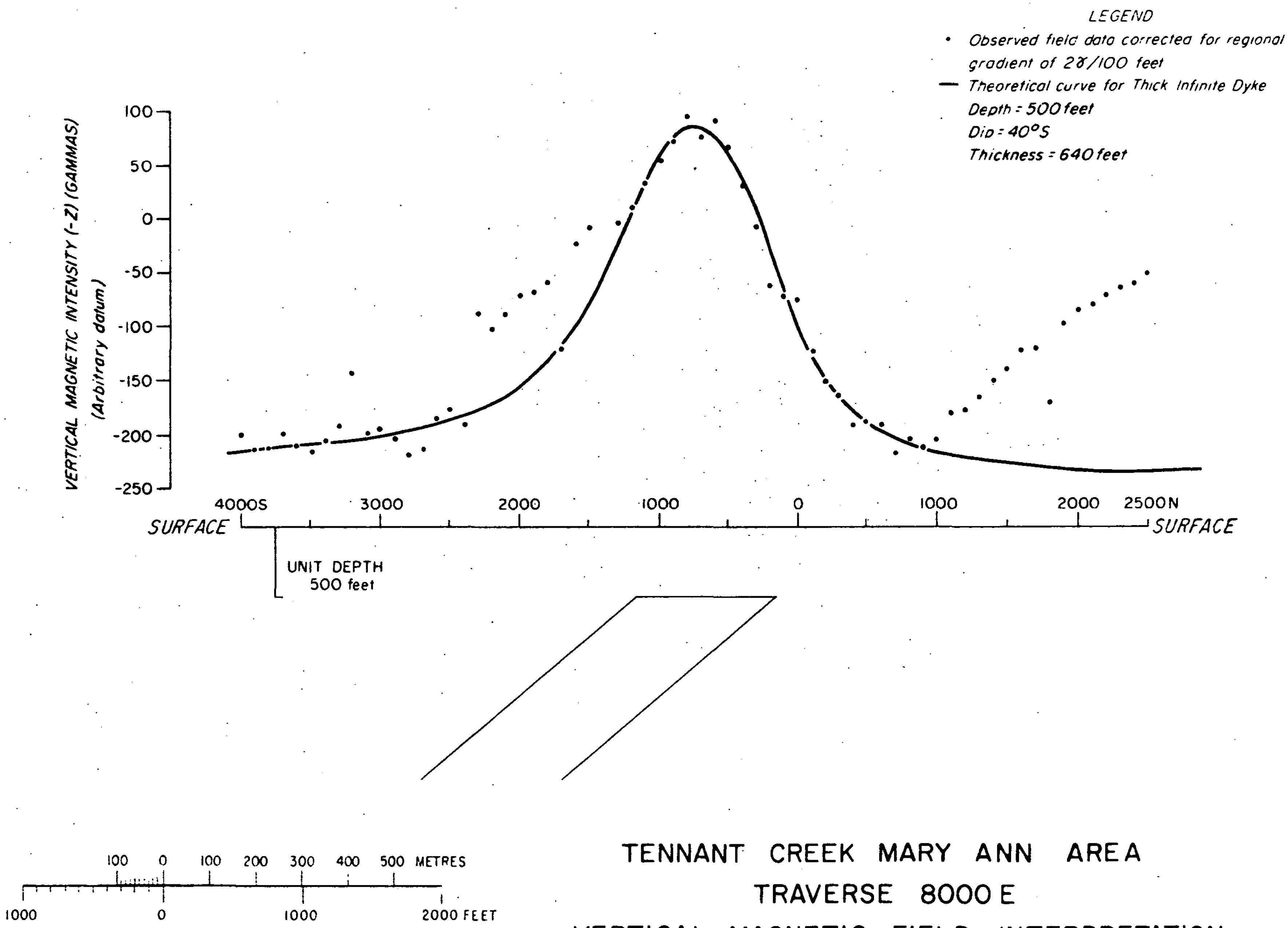

# TENNANT CREEK MARY ANN AREA

## TRAVERSE 11200 E

## GRAVITY PROFILE AND INTERPRETATION

PLATE 16

E 53/B7-155A

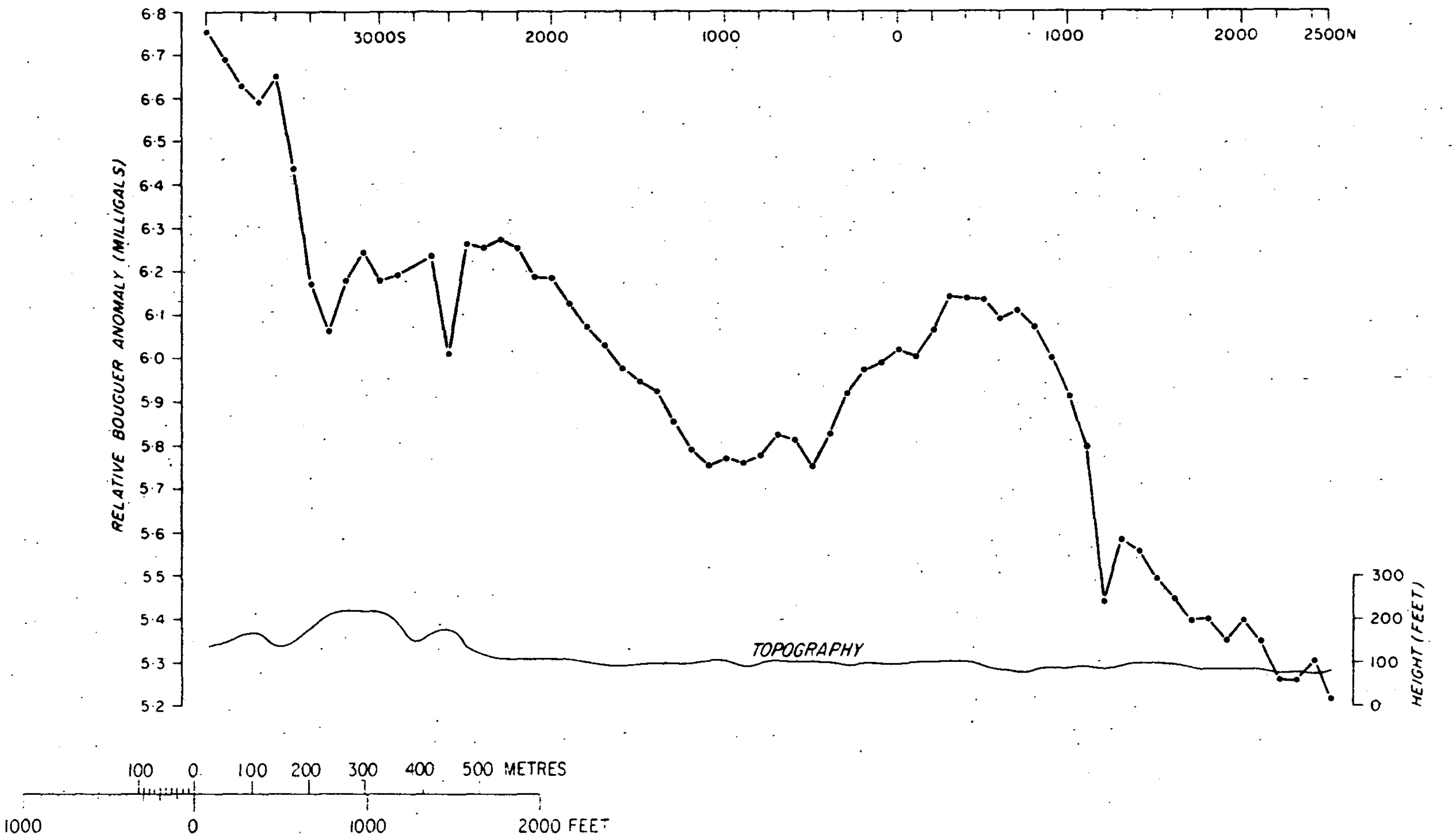



# TENNANT CREEK MARY ANN AREA
## TRAVERSE 8000 E
## VERTICAL MAGNETIC FIELD INTERPRETATION

PLATE 17

E53/B7-136A

Record No. 1974/80

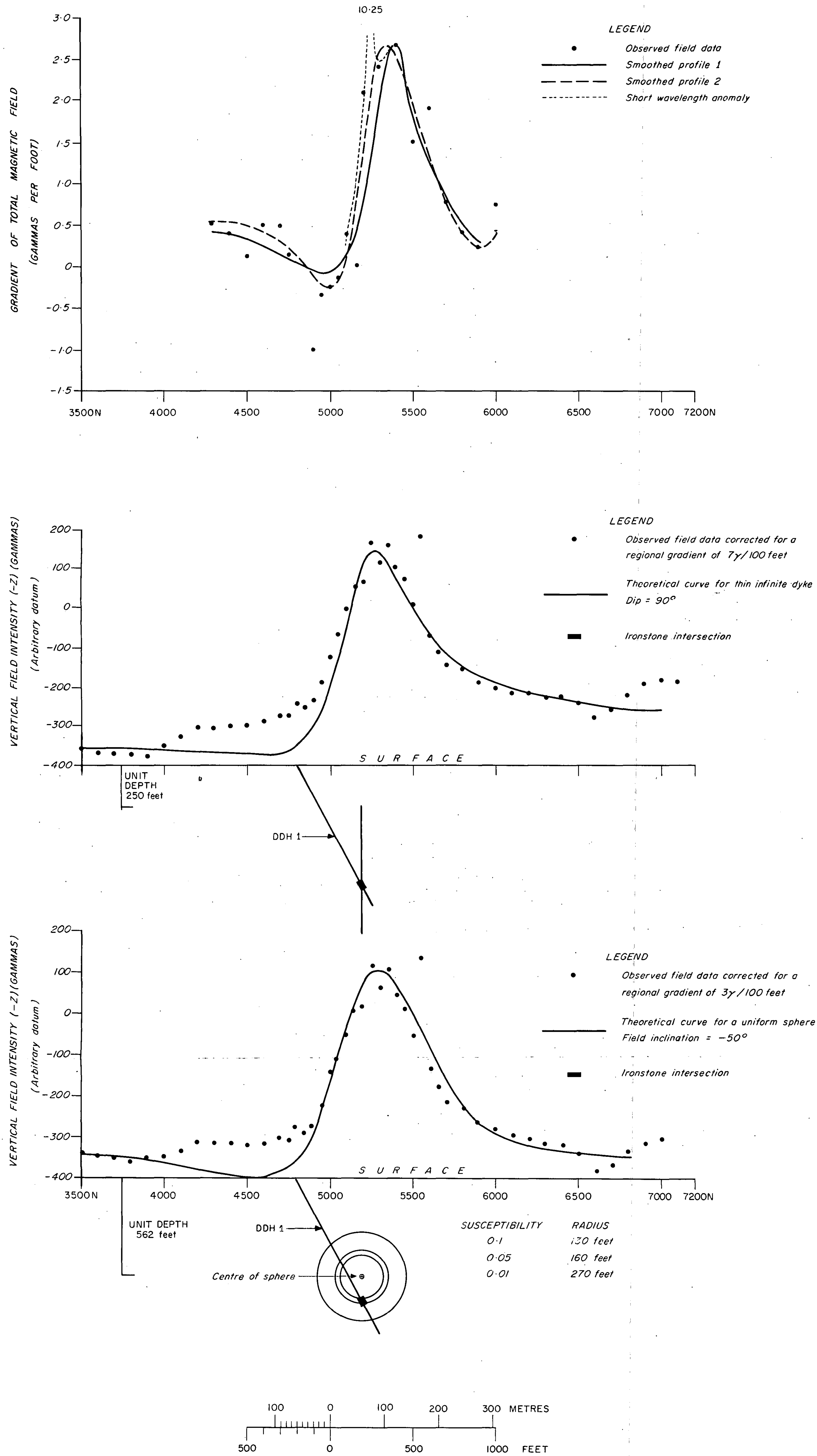



Density used for corrections = 2 6 g/cm³

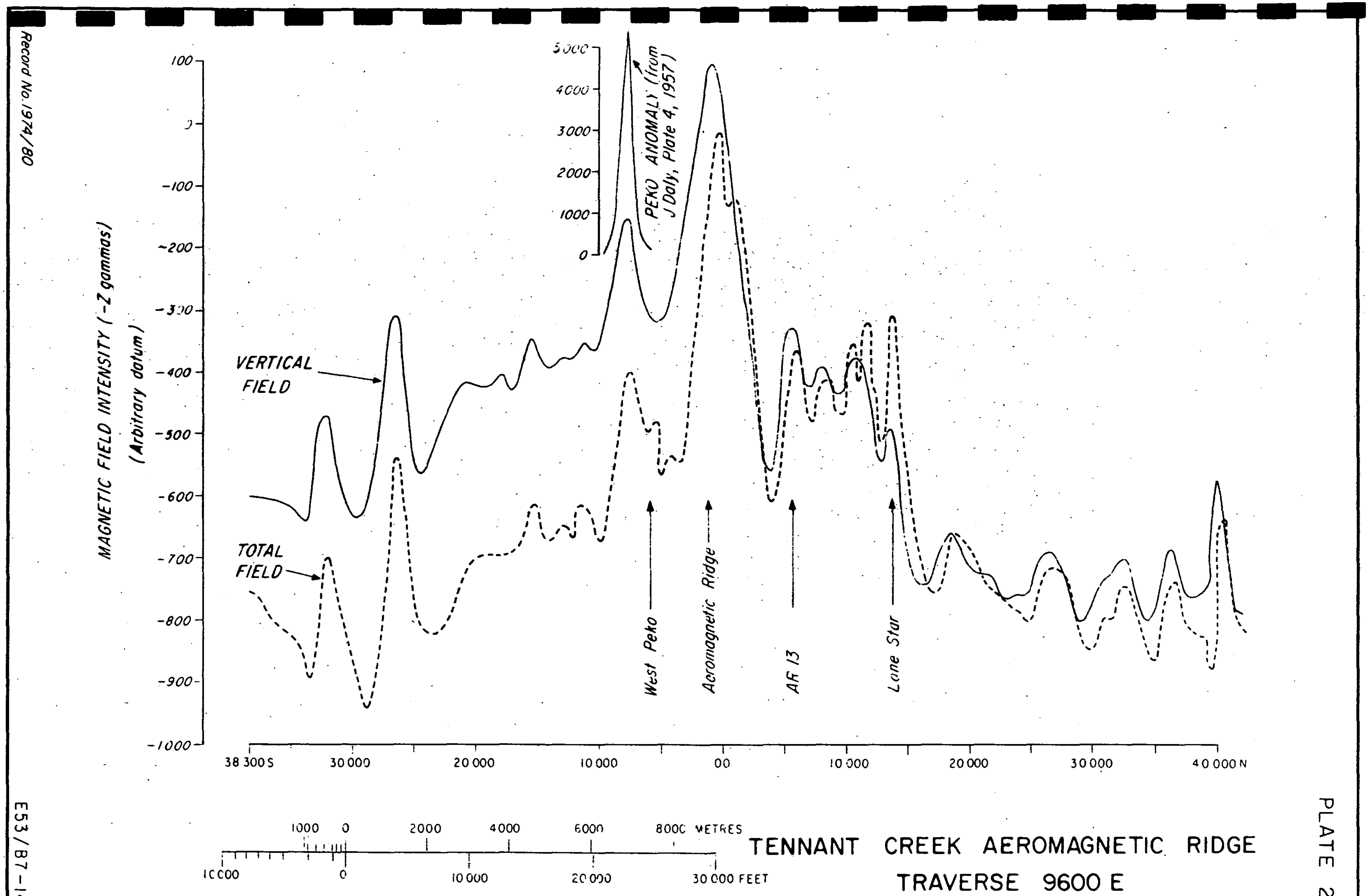
# TENNANT CREEK MARY ANN AREA
## TRAVERSE 8000 E
## BOUGUER GRAVITY AND TOPOGRAPHIC PROFILES

E53/B7-156A

PLATE 18




# TENNANT CREEK, AREA AR 2 TRAVERSE 7000 W
## MAGNETIC PROFILES AND INTERPRETATION




TENNANT CREEK AEROMAGNETIC RIDGE

TRAVERSE 9600 E

VERTICAL AND TOTAL MAGNETIC FIELD PROFILES

PLATE 20

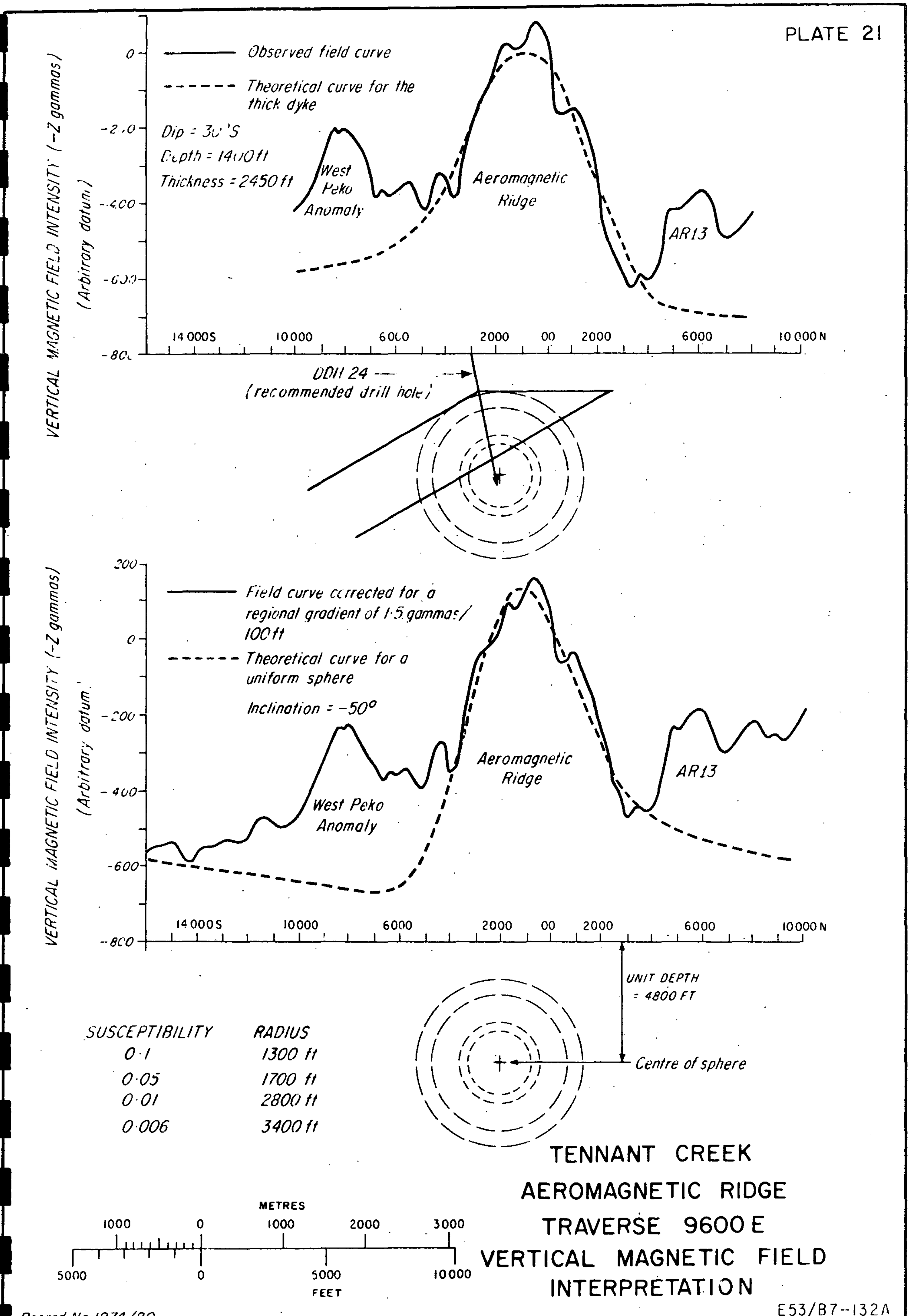
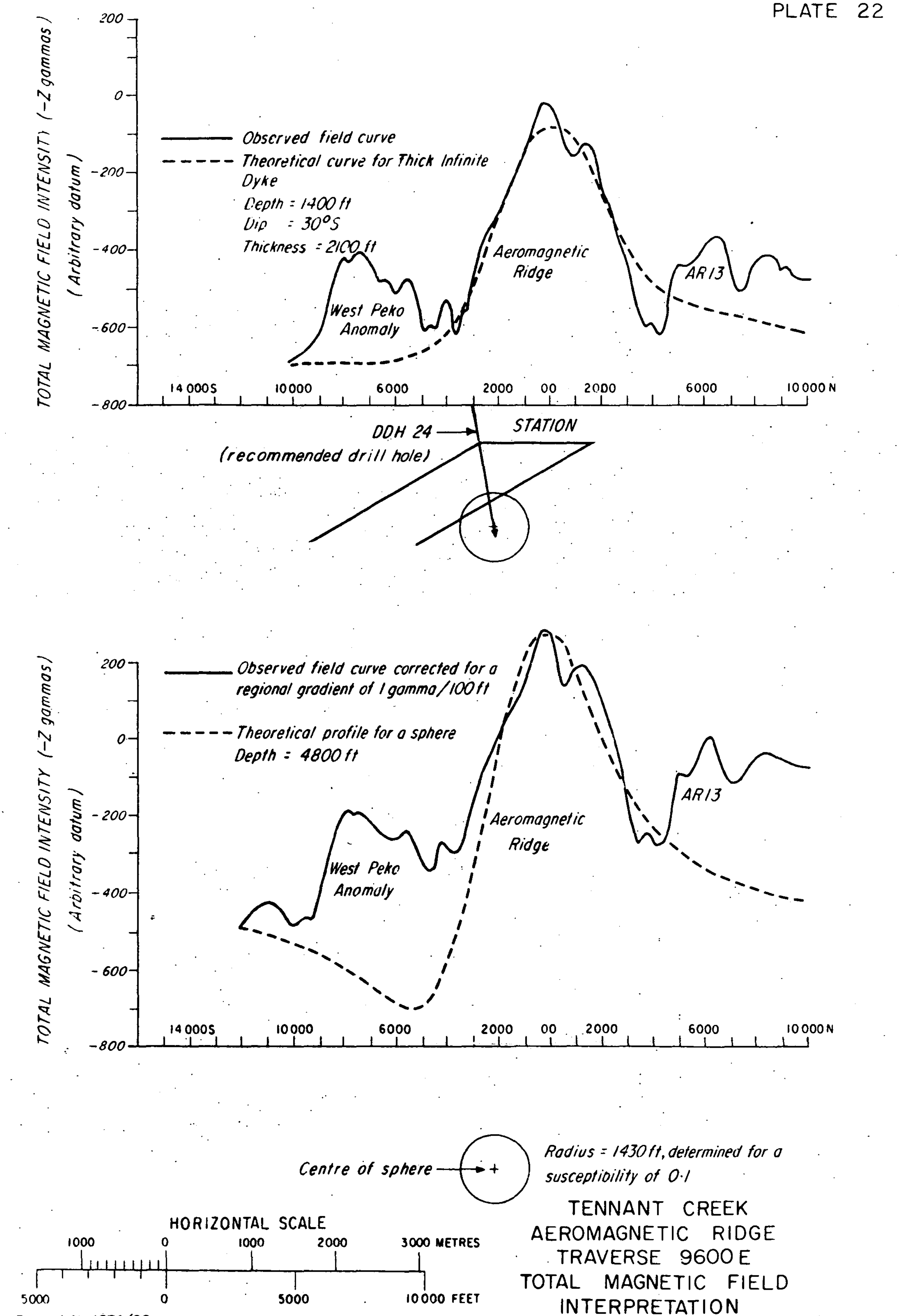


PLATE 21
Observed field curve
Theoretical curve for the thick dyke
Dip = 30°S
Depth = 1400 ft
Thickness = 2450 ft
West Peko Anomaly
Aeromagnetic Ridge
AR13
VERTICAL MAGNETIC FIELD INTENSITY (−Z gammas)
(Arbitrary datum)
0
-200
-400
-600
-800
14 000 S
10 000
6000
2000
00
2000
6000
10 000 N
DDH 24 — (recommended drill hole)
Field curve corrected for a regional gradient of 1·5 gammas/100 ft
Theoretical curve for a uniform sphere
Inclination = −50°
200
0
-200
-400
-600
-800
West Peko Anomaly
Aeromagnetic Ridge
AR13
14 000 S
10 000
6000
2000
00
2000
6000
10 000 N
UNIT DEPTH = 4800 FT
Centre of sphere
SUSCEPTIBILITY
RADIUS
0·1
1300 ft
0·05
1700 ft
0·01
2800 ft
0·006
3400 ft
METRES
1000
0
1000
2000
3000
5000
0
5000
10 000
FEET
TENNANT CREEK
AEROMAGNETIC RIDGE
TRAVERSE 9600 E
VERTICAL MAGNETIC FIELD
INTERPRETATION
Record No. 1974/80
E53/B7–132A

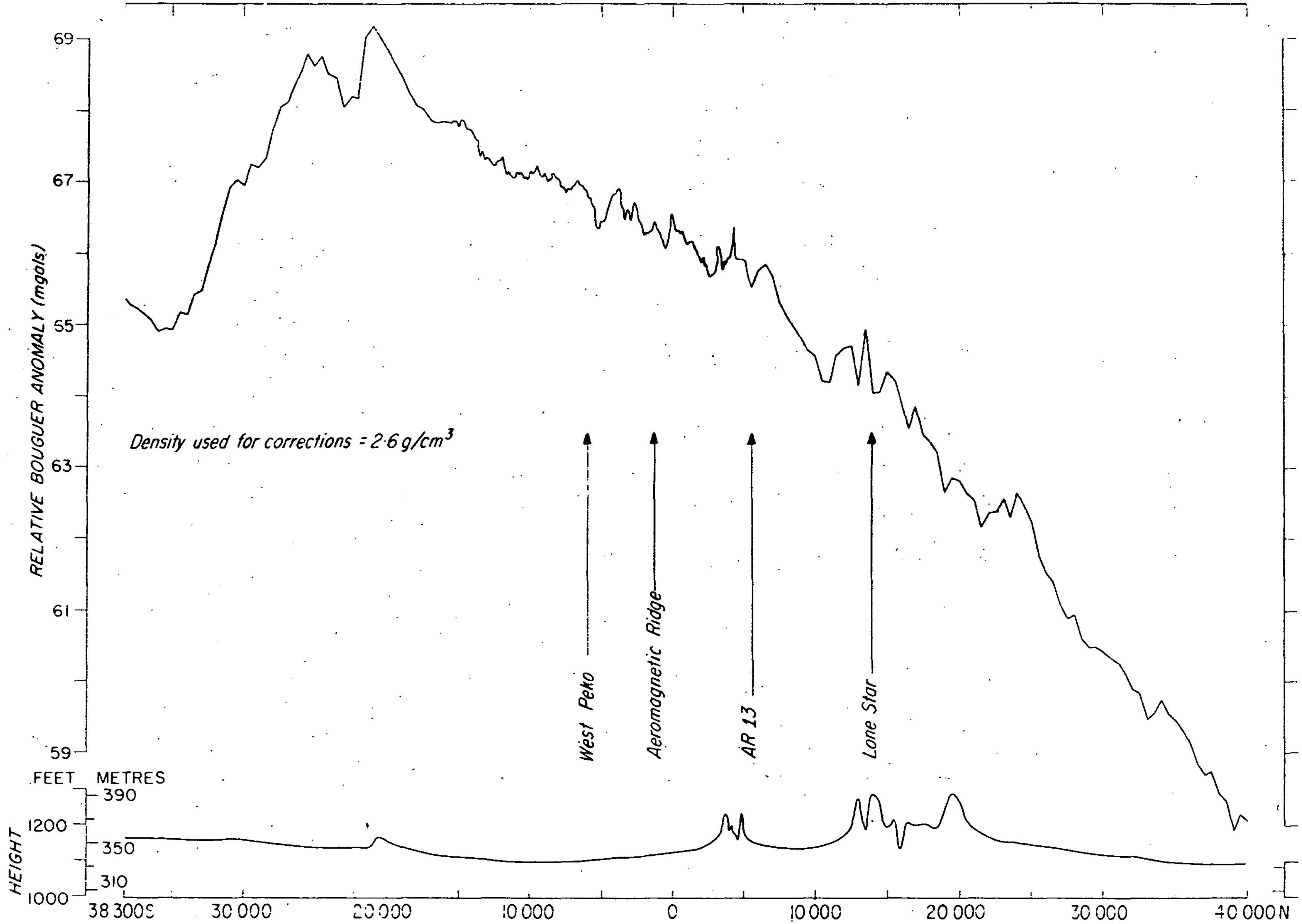
PLATE 22

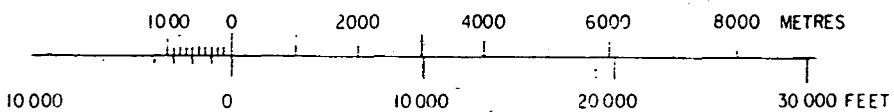



TENNANT CREEK
AEROMAGNETIC RIDGE
TRAVERSE 9600 E
TOTAL MAGNETIC FIELD
INTERPRETATION

E53/B7-151A

Record No. 1974/80



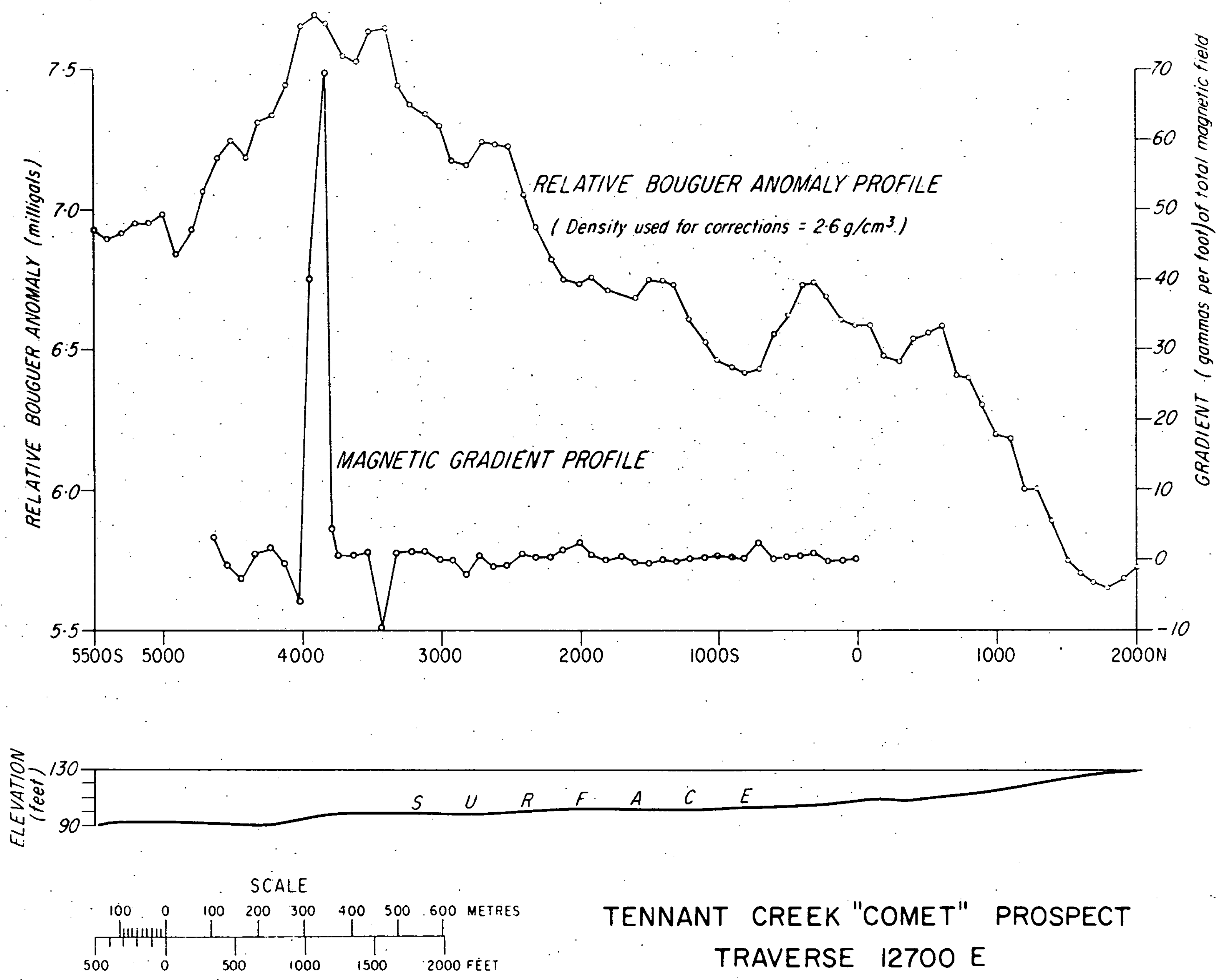




# TENNANT CREEK AEROMAGNETIC RIDGE

## TRAVERSE 9600 E GRAVITY PROFILE

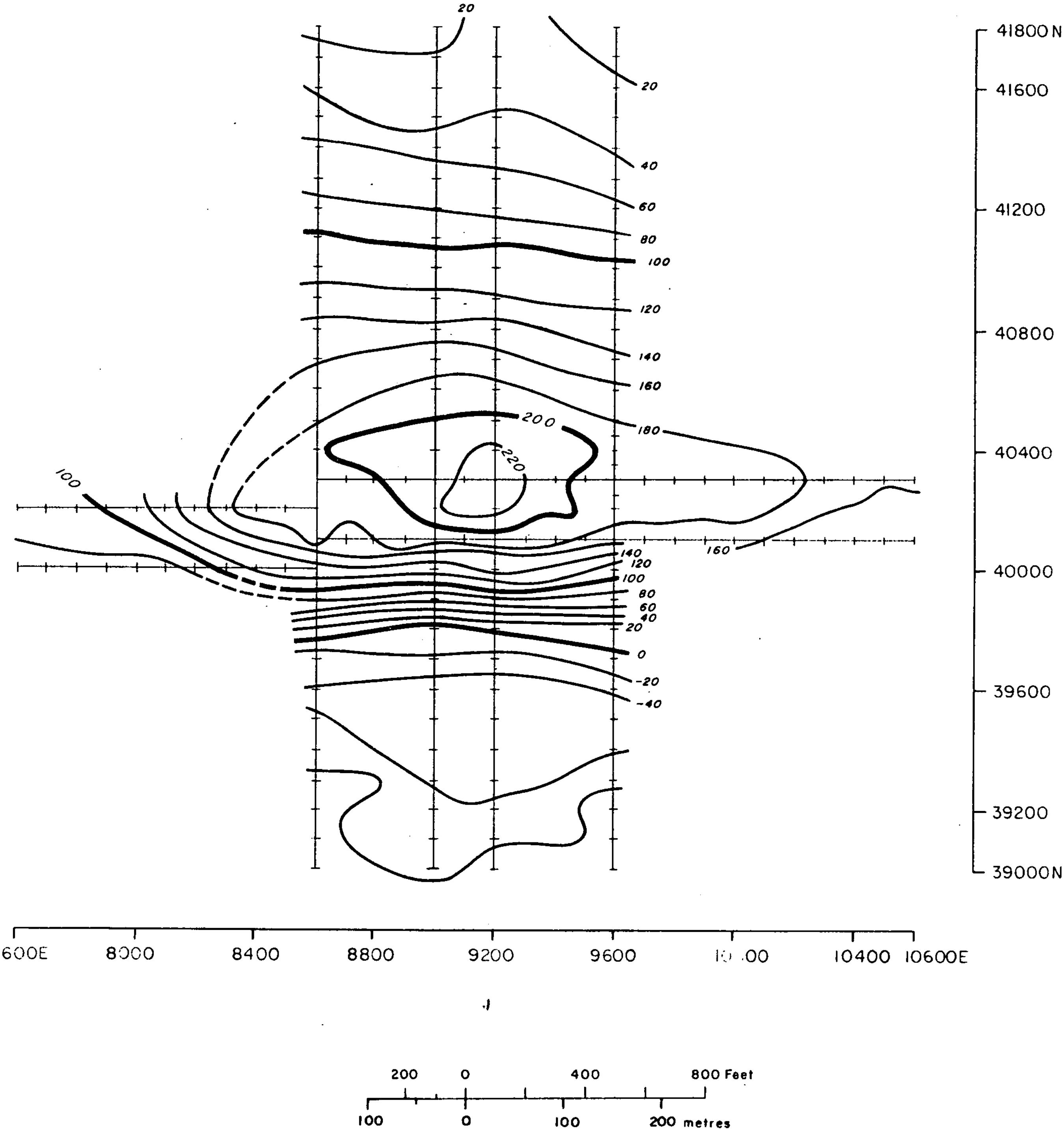
E53/B7-150A

PLATE 23




# TENNANT CREEK "COMET" PROSPECT
## TRAVERSE 12700 E
## MAGNETIC AND GRAVITY PROFILES

PLATE A1



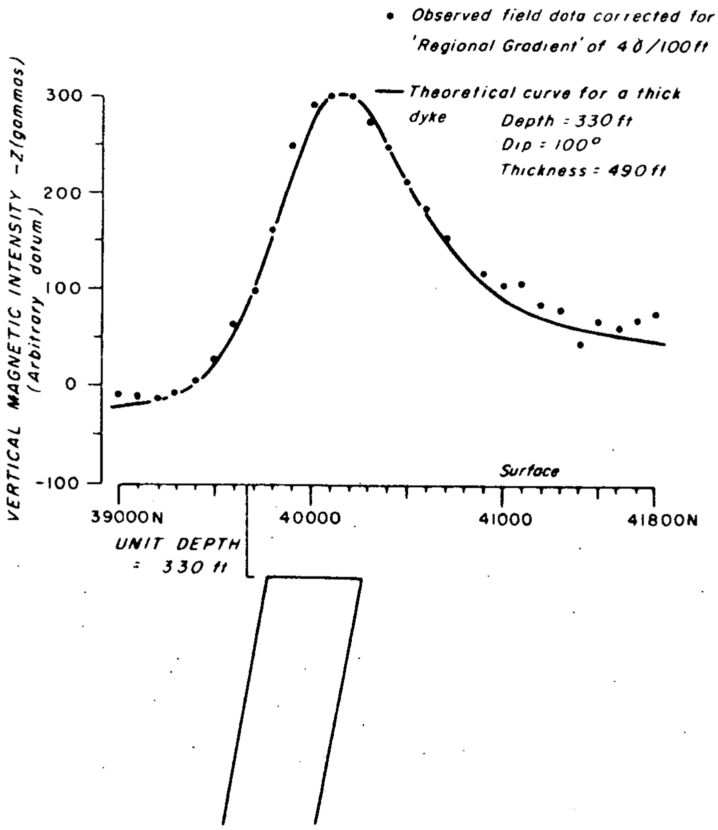

# TENNANT CREEK

## AEROMAGNETIC RIDGE-9200E (EXTENDED) AREA

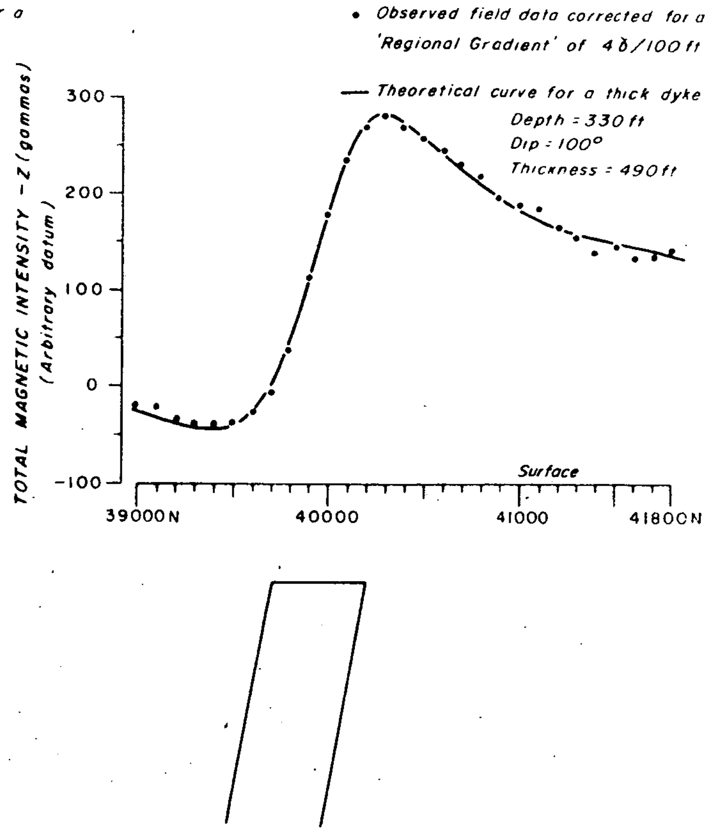
## TRAVERSE PLAN AND TOTAL MAGNETIC FIELD CONTOURS

*Record No.1974/80*

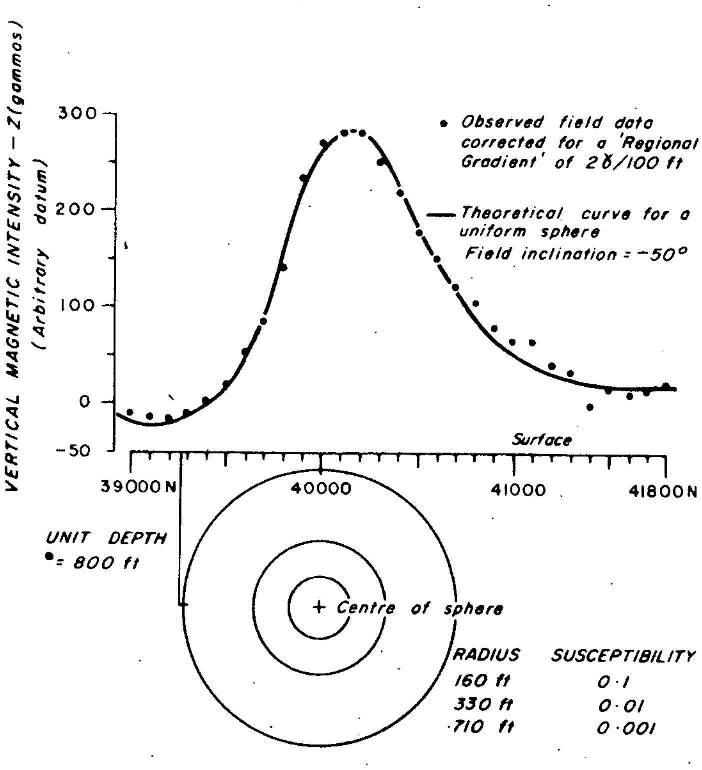
E 53/B7-173A

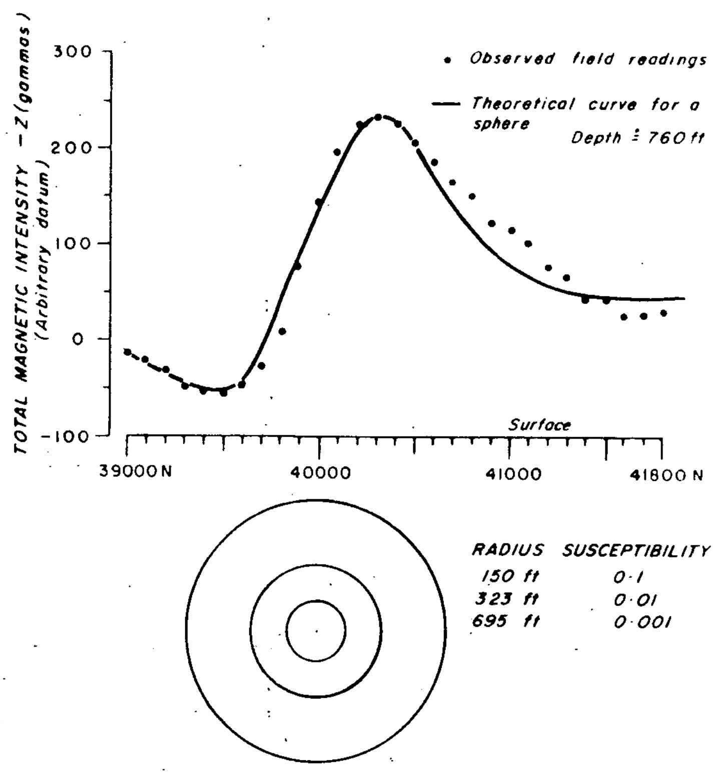



VERTICAL MAGNETIC FIELD INTERPRETATION




TOTAL MAGNETIC FIELD INTERPRETATION




TOTAL MAGNETIC FIELD INTERPRETATION

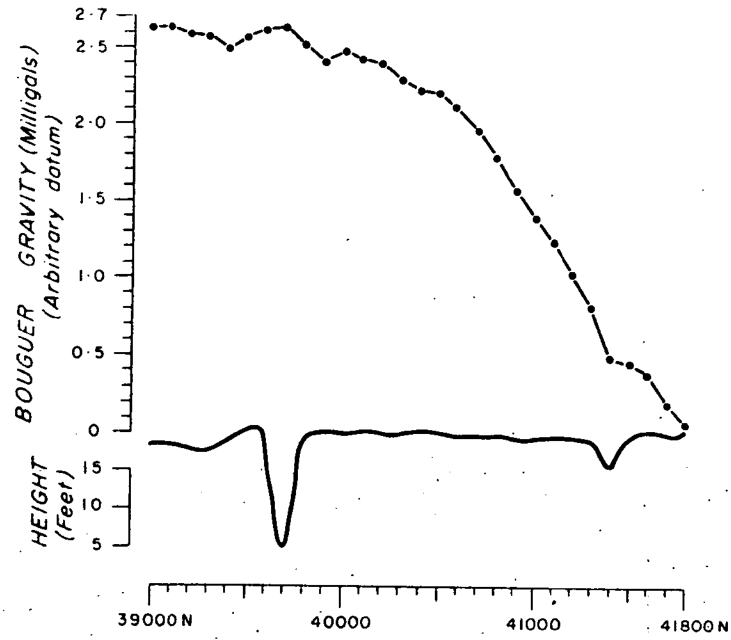
VERTICAL MAGNETIC FIELD INTERPRETATION

# TENNANT CREEK
## AEROMAGNETIC RIDGE TRAVERSE 9200 E (EXTENDED)
## INTERPRETATION OF MAGNETIC DATA

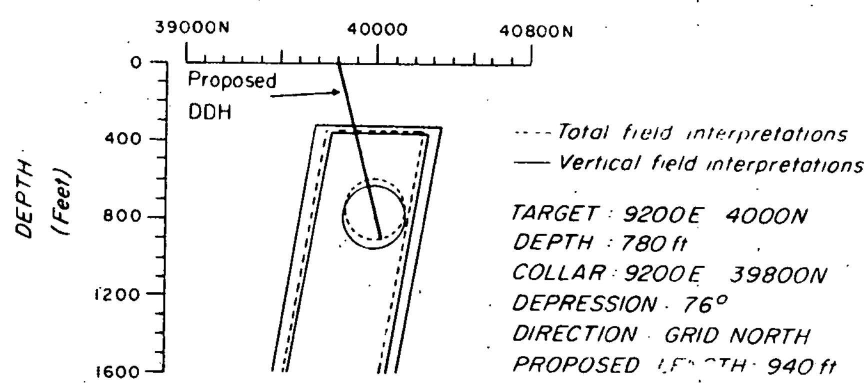
Record No 1974/80

E53/B7-174 A

PLATE A3




BOUGUER GRAVITY AND TOPOGRAPHIC PROFILES




INTERPRETED BODIES AND DRILLING RECOMMENDATION

# TENNANT CREEK
# AEROMAGNETIC RIDGE
# TRAVERSE 9200E (EXTENDED)