DEPARTMENT OF MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1974/167

TRANSIENT ELECTROMAGNETIC TESTS NT and QLD, 1972

by

B.R. Spies

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SUMMARY

Test surveys of the Russian-built transient electromagnetic prospecting equipment MPPO-1 were conducted at four localities in northern Australia: Tennant Creek, Rum Jungle, and Mary River in NT; and Cloncurry, Qld. Results obtained were interpreted with reference to known geology and other geophysical information.

Good agreement was generally obtained between the transient E.M. results and those observed with other E.M. methods. Good correlation was obtained with geology. It was found that the transient E.M. equipment could be used in areas where topography or highly conductive surface conditions severely limited the effectiveness of other geophysical methods. The use of loops 100-150 m in size enabled large areas to be surveyed fairly quickly. Smaller loops proved useful in accurately delineating anomalies. It is apparent that different loop sizes with loop overlap must be used to assist quantitative interpretation.

The theoretical advantages inherent in the transient E.M. system make the method attractive under Australian conditions. The main difficulty encountered was that of electrical interference. The low power of the MPPO-1 equipment limits the signal-to-noise ratio and thereby depth penetration.

1. INTRODUCTION

Electromagnetic (E.M.) methods have been used in mineral exploration for more than 50 years. Most systems operate in the frequency domain involving continuous transmission at a fixed frequency. Recently, time-domain E.M. systems have come into use, in which a series of pulses are transmitted and the decay of the resultant transient secondary field is recorded during the transmitter off-time. The name commonly applied to such systems is transient E.M. (T.E.M.).

The theory of the application of E.M. transients in prospecting for highly conductive orebodies was developed by Wait (1951). Since that time, Russian investigators have been particularly active in the development and application of the method. The Russian system MPPO-1 has been in use in the USSR for a number of years and was first made available to non-Communist countries in 1966. No other ground transient E.M. systems are commercially available.

In April 1972 the Bureau of Mineral Resources (BMR) purchased an MPPO-1 system and subsequently conducted field tests in northern Australia later that year during August to October.

Areas selected for the test surveys included Tennant Creek, where geophysical and geological controls are available over known ironstone bodies, and two areas at Rum Jungle (Mount Minza and Woodcutters L5 Prospect) where a well-defined highly conducting shale bed and a gossan occur respectively. More extensive surveys were also carried out at Mary River in the Northern Territory and Cloncurry in Queensland in conjunction with the 1972 Mary River and Cloncurry, geophysical surveys, thereby allowing T.E.M. results to be compared with other metalliferous geophysical results.

2. EQUIPMENT AND OPERATIONAL THEORY

General description

The MPPO-1 transient electromagnetic prospecting equipment operates by inducing eddy currents in the ground and analyzing their decay. This provides information on subsurface conductors. A single ungrounded loop both transmits the primary energizing field and senses any secondary currents set up by subsurface conductors. The equipment, consisting essentially of a voltage pulse generator/secondary signal measuring unit, power supply unit, and transmitter/receiver loops of various sizes is illustrated in Figure 1.

The generating/measuring unit produces periodic rectangular current pulses at 18 Hz in the loop laid out on the ground surface. The amplitude of these primary field pulses is 5 volts, which limits the transmitter current to ½ to 2 amps depending on the loop size used. The power supply unit contains rechargeable silver-zinc batteries for supplying the primary current.

If a conductor is present in the vicinity of the loop, the sudden change in magnetic field at the edge of a current pulse will induce eddy currents in the conductor, and these currents tend to oppose the decay of the field. Such eddy currents produce a secondary electromagnetic field which will decay with time in the same manner as the eddy currents. A time-dependent emf, e(t), is thereby induced in the loop in the interval between the current pulses and is proportional to the time derivative of the secondary magnetic field; e(t) is the voltage at time t in milliseconds, such that e(1.1) is the voltage measured at 1.1 ms, for example.

The measuring unit amplifies the signal received from a loop at a given time t after pulse termination, and averages it over several hundred cycles yielding the emf value e(t). This emf is read off a millivoltmeter at any one of 12 discrete sample times which range from t = ½ ms to 15 ms.

The results of measurements are presented in the form of reconstructed decay curves, or profiles or contours of e(t) at different sample times. In practice, it is more convenient to deal not with e(t)/I but with the e(t)/I ratio, where I is the current in the loop, the results thus being normalized for different values of the primary current.

The attenuation of eddy currents increases as conductivity and size of the conductor decrease. Consequently it is theoretically possible to select a sample time at which the signal produced by a poor to moderate conductor, such as conductive overburden, has been attenuated to the extent that an additional response produced by a strong and possibly deeper conductor becomes clearly resolvable. A comparison of the anomalies recorded at different sample times serves to indicate the conductivity of the causative source in a similar manner to variable-frequency measurements with continuous-wave methods.

Detailed equipment operation

Figure 2 illustrates the functional operation of the MPPO-1 equipment. A master oscillator generates pulses 20 ms wide at 18 Hz which activate a current switch, thereby applying the primary field pulses to the loop. A commutator switches in the receiver amplifier in the interval between the primary current pulses. The drive to this amplifier is delayed as shown in

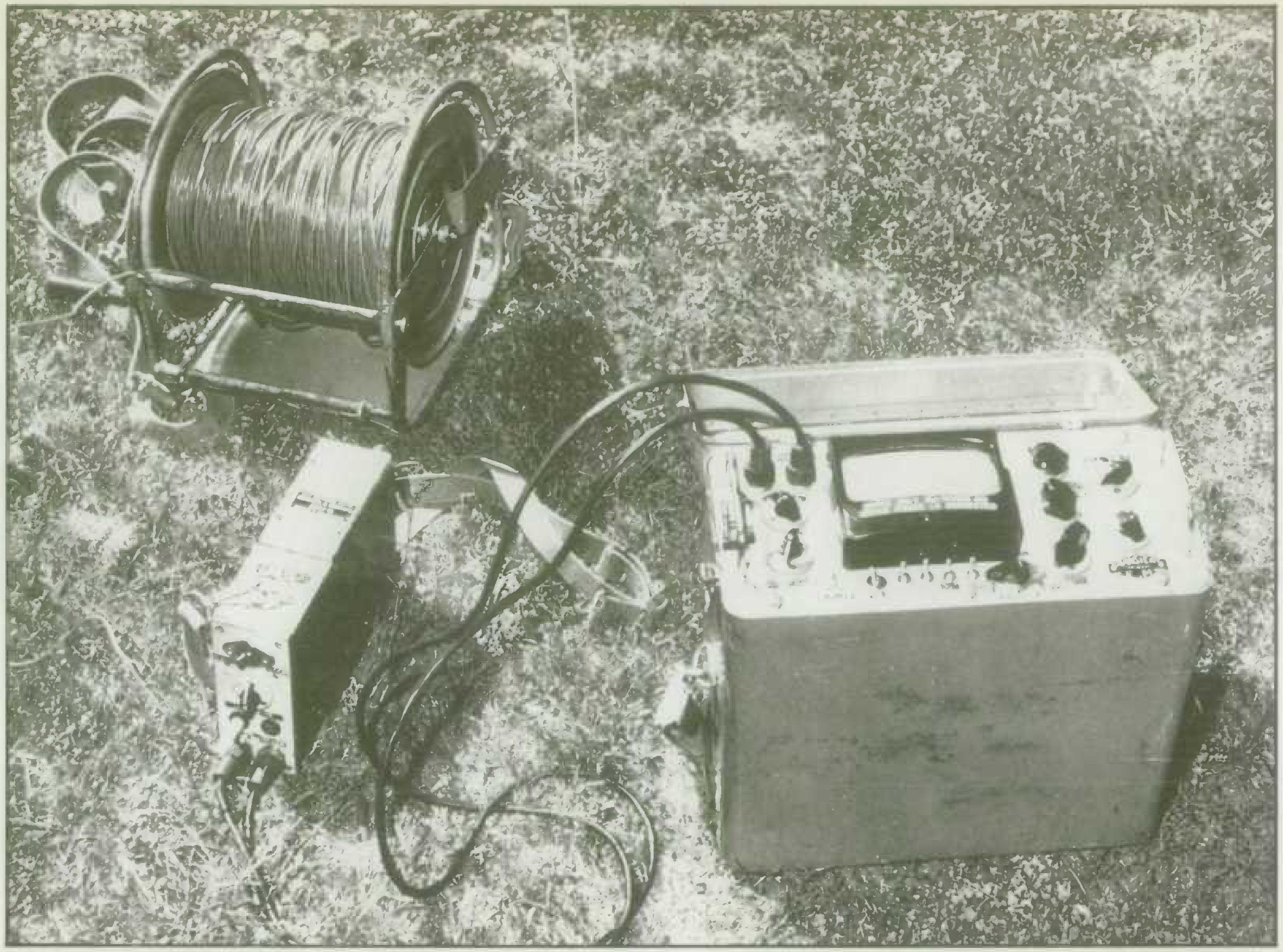


Fig. 1 MPPO-1 PROSPECTING EQUIPMENT

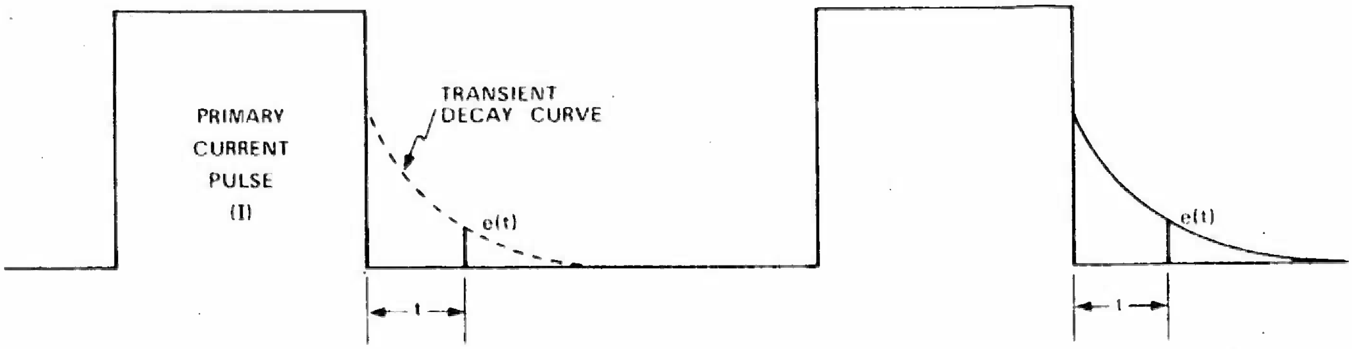


Fig. 2a OPERATION PRINCIPLES OF MPPO-1

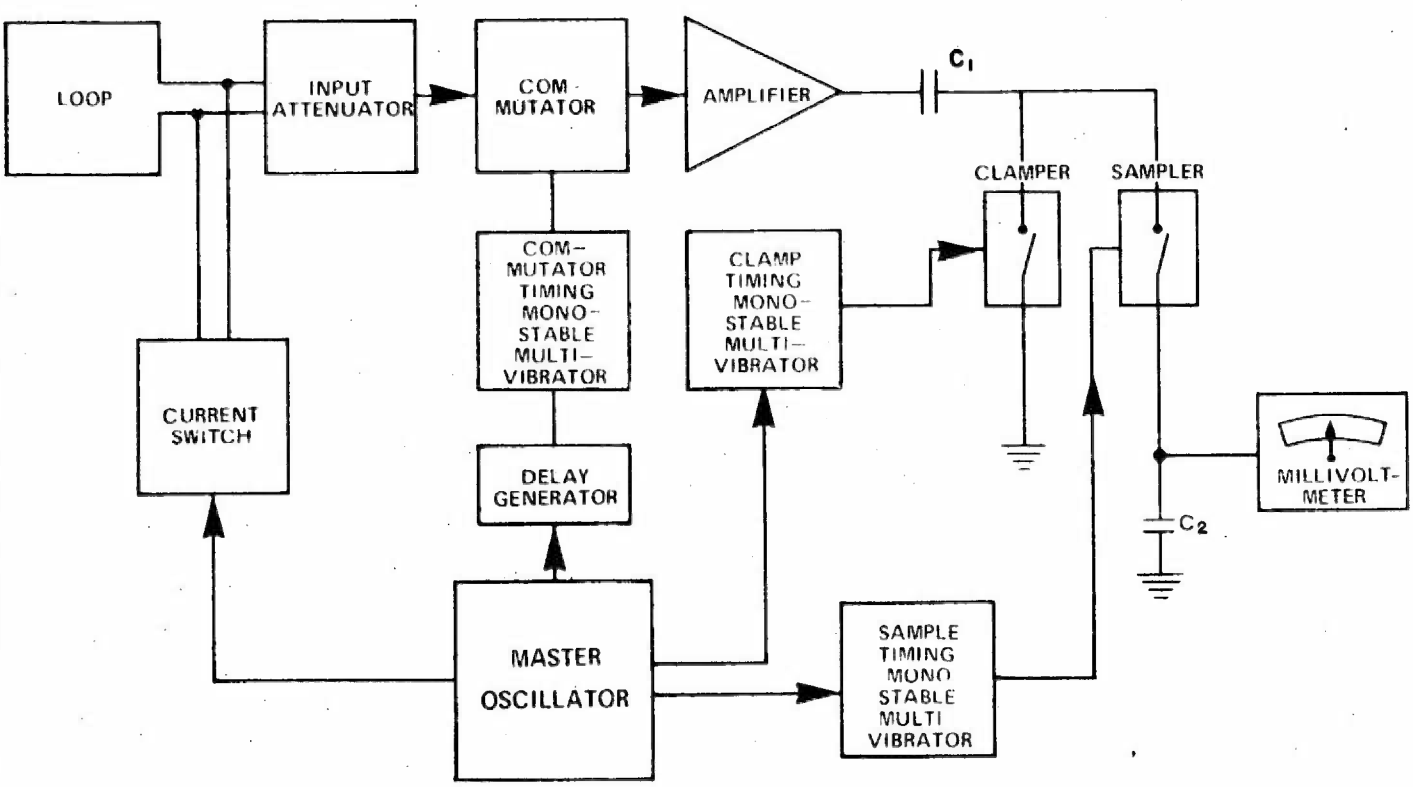


Fig. 2b SIMLIFIED BLOCK DIAGRAM OF MPPO-1 EQUIPMENT

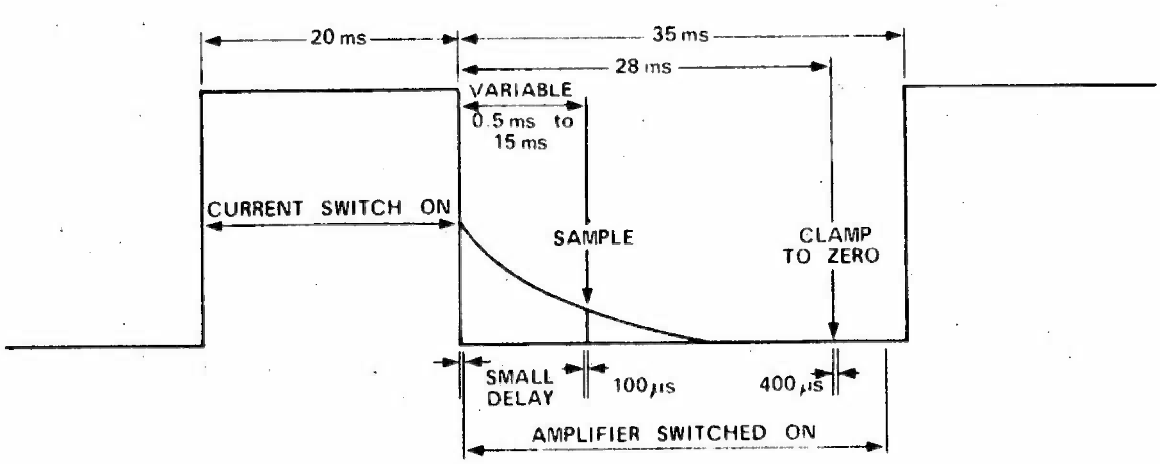


Fig. 2c DIAGRAM SHOWING TIMING OF VARIOUS COMPONENTS OF MPPO-1

Fig. 2 OPERATION PRINCIPLES OF MPPO-1

Figure 2c to ensure that the current pulses have fallen off adequately to avoid saturation of the receiver amplifier at early sample times. The clamp-timing monostable multivibrator produces pulse 400 microseconds 28 ms after the fall of the current pulse and activates the clamper so that voltages e(t) read off the decay curve at different sample times are with respect to an origin (zero value) at 28 ms.

The sample timing monstable multivibrator has a variable pulse duration from ½ ms to 15 ms which is set manually by a switch on the front panel of the instrument. Nominal sample times available are 0.57, 0.79, 1.12, 1.56 2.34, 3.18, 4.08, 5.16, 6.01, 8.22, 10.09 and 15.27 ms (0.57 and 0.79 ms being a BMR modification). At the fall of the pulse in this monostable multivibrator, the sampler switch is closed for 100 microseconds during which time capacitor C_1 transfers charge to the storage capacitor C_2. After several hundred cycles the full value of the voltage e(t) is developed across C_2 and may be read off the millivoltmeter, measurements from to 50 000 microvolts being made possible by an input attenuator. The voltmeter has a very large input impedance, in excess of 50 megohms, so that the voltage in C_2 does not vary between samples.

3. INTERPRETATION OF T.E.M. DATA

The transient decay curve is generally not of simple exponential form, but rather a sum of exponential decays, and the analysis of its shape is important in the interpretation of results.

An exponentially decaying quantity can be expressed as

$$a = A \exp(-t/\tau) \qquad (1)$$

where a = instantaneous value

A = initial amplitude

t = time

τ = time constant of the decay

When $t = \tau$, the exponential factor has reduced to 1/e or 37% of its initial value. Rewriting (1) in logarithmic form gives

$$\ln a = - t/\tau + \ln A \qquad (2)$$

which is the equation for a straight line with a negative slope equal to $1/\tau$ and y-axis intersection of ln A.

A transient decay which is the sum of exponentials will have a time constant $\tau(t)$, which will vary with time. When a sufficiently large time has elapsed from the start of the transient decay, the response is represented by a fixed decay constant, τ_o. If this decay constant can be determined, the conductivity and size of the conductor(s) can be estimated.

The transient decay curve can be plotted on linear-linear, log-linear or on log-log scales as shown in Figures 3a, 3b, and 3c.

The log-linear scale is best used for determining the time constants of the transient decay, as these are simply the reciprocal of the slope of the curve. For large times the time constant tends towards a fixed value τ_o, as previously mentioned. Time constants are shown in Figure 3d in the form of a $\tau(t)$ curve. In the example τ_o is about 5.5 ms.

Velikin & Bulgakov (1967) state that

$$\tau(t) \rightarrow \tau_o = \mu \sigma Q \qquad \text{seconds} \qquad (3)$$

where μ= magnetic permeability, usually taken as equal to μ_o (the permeability of free space) = $4\pi \times 10^{-7}$ henry/m

σ = conductivity of the body in siemens/m

Q = effective cross-section of the body.

According to Velikin & Bulgakov, values of τ_o greater than 10 ms indicate commercial orebodies. By plotting decay curves from different localities on one graph it is possible to compare the amplitude and shape of the decays. It is usually easier to compare the decays if they are plotted on a log-log scale as demonstrated in Figure 3c. With such a data display, relative amplitudes at different times are readily discernible. On a $\tau(t)$ display it is easier to compare the relative rates of decay. Two curves may be separated vertically on the log-log data display but have the same rate of decay (i.e., only the amplitudes differ). Such curves will coincide on a $\tau(t)$ graph. Velikin & Bulgakov employ a procedure known as 'parallel vertical transfer', which involves moving curves vertically on a log-log or log-linear scale to compare their rates of decay. If the time constants are similar the curves will coincide.

Although the transient curve involves the whole frequency spectrum, different elements contain differing proportions of high- and low-frequency components. Morrison Phillips & O'Brien, (1969) point out that at early times the response is due to both low- and high-frequency groups whilst at later times only the low-frequency response remains and that this hypothesis, coupled with the fact that skin depth varies inversely as the square root of the

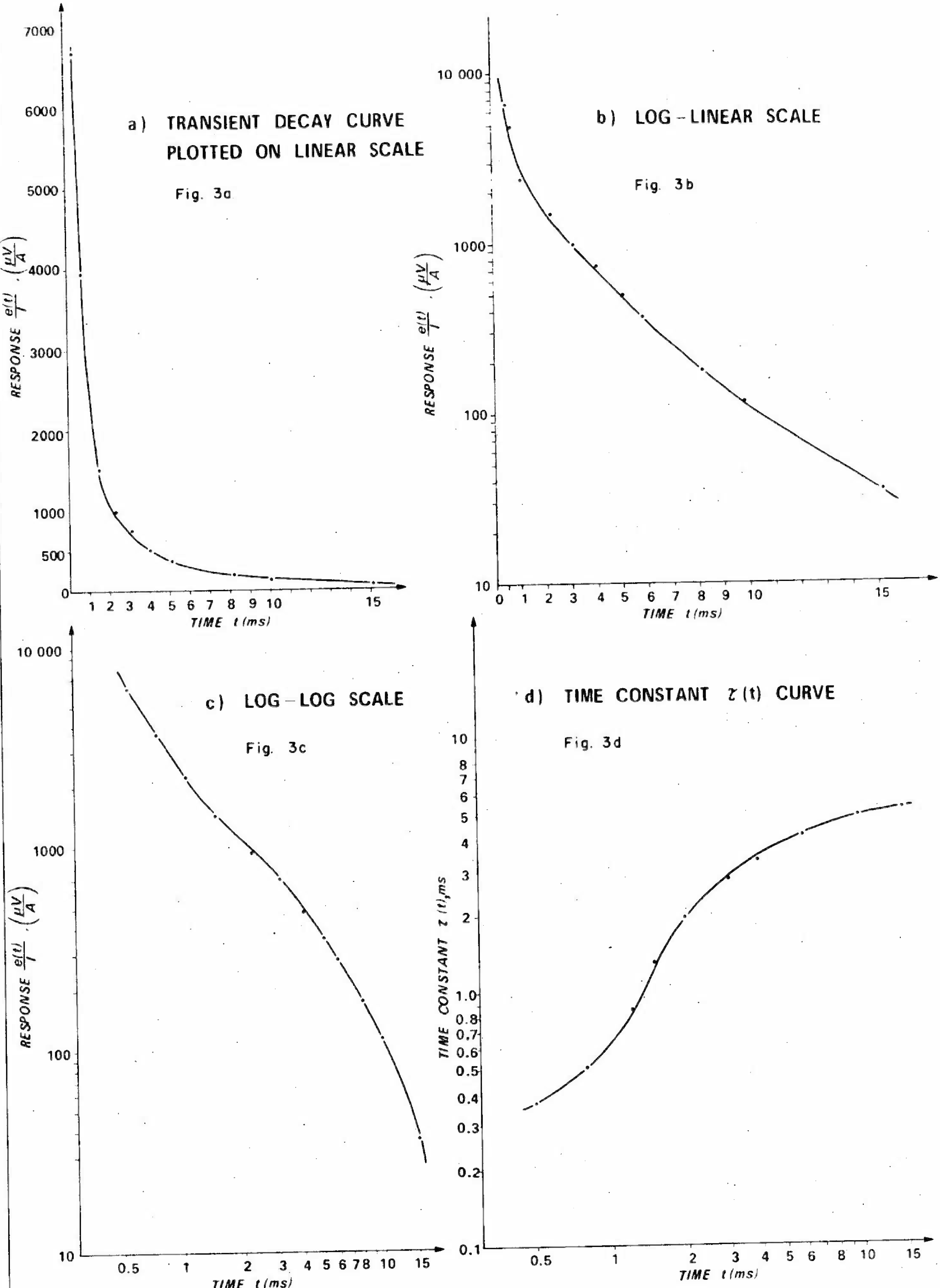
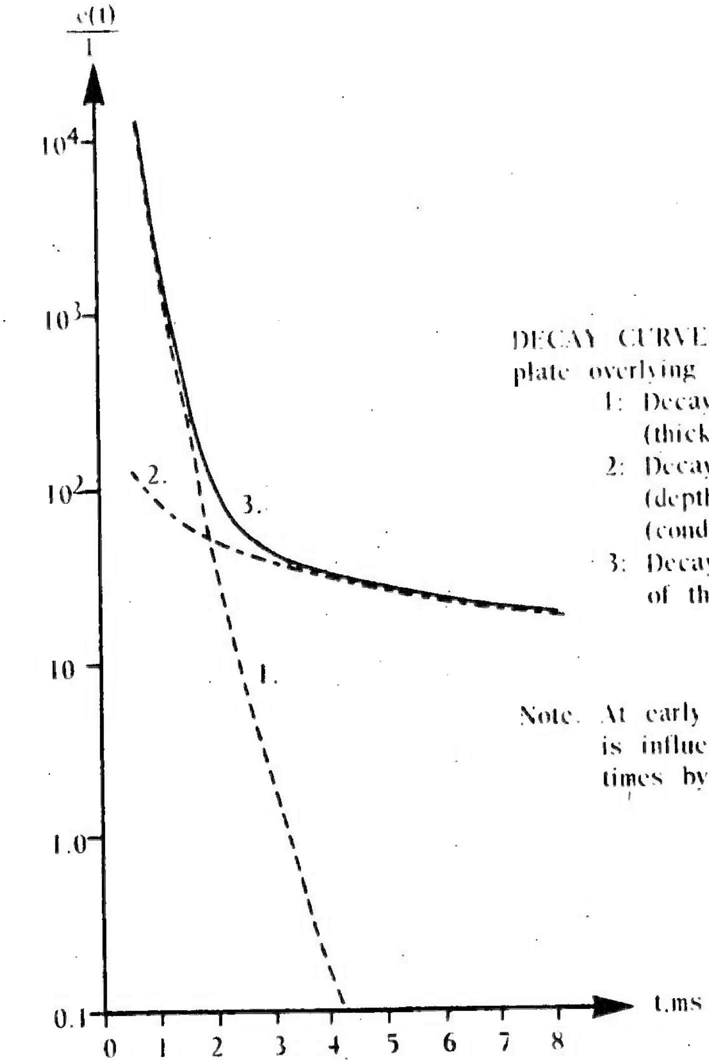


Fig. 3 TRANSIENT DECAY CURVES

Fig. 4

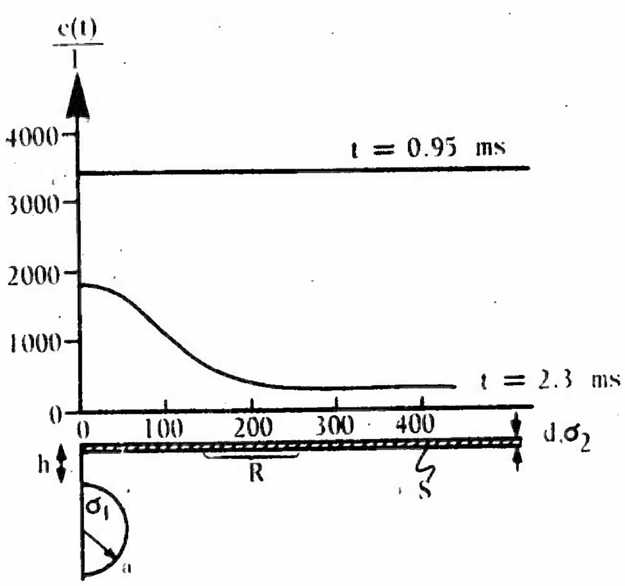
TIME CHARACTERISTICS OF A SPHERE UNDER A CONDUCTIVE LAYER. (After VELIKIN & BULGAKOV, 1967)



DECAY CURVES at the surface of a thin conducting plate overlying a conducting sphere

1: Decay curve of a plate (thickness x conductivity = 3 siemens)
2: Decay curve of a sphere (depth to top = 30 m) (conductivity = 58 siemens/m)
3: Decay curve of a sphere in the presence of the plate

Note. At early times the total transient decay curve is influenced mainly by the plate and at later times by the sphere



PROFILES of $\frac{e(t)}{I}$ over a thin conducting plate overlying a conducting sphere.

σ_1 = 58 siemens/m

$S = d.\sigma_2$ = 3 siemens

a = 30 m

R (half loop size) = 100 m

h = 30 m

frequency, suggests that the early part of the transient response is governed by the rapid decay at shallow depths whilst the later part of the response is due to the lower-frequency energy, which has penetrated to greater depths.

Velikin & Bulgakov (1967) conducted a model experiment which clearly showed the value of data obtained from a transient electromagnetic system. A conductive sphere representative of an orebody was placed beneath a thin conductive plate representing a less conductive surficial layer. At early stages of the transient, the composite system response differed little from that due solely to the overlying sheet whilst at later stages it corresponded to that of the sphere alone, as shown in Figure 4. The result has been proved theoretically by Wait (1956) and Negi and Verma (1972).

In order to interpret adequately the results from a T.E.M. survey, e(t)/I values for selected sample times are first plotted in the form of profiles or contours of response. Areas of near-surface high conductivity can then be outlined by taking e(t)/I contours at early sample times (1 or 2 ms). Such areas with a thin horizontal conductive sheet are characterised by simple exponential responses (Velikin & Bulgakov, 1967; Becker, 1969). The former workers have defined the product of the thickness and conductivity of a sheet as 'Lateral Conductivity', S, where S is given (at early times only) by the formula

$$\frac{e(t)}{I} = \frac{3\pi}{16} \times \frac{1}{S} \times \frac{SR^4}{t}$$

Taking $\mu = \mu_0$, this reduces to

$$S = \left(\frac{6.81}{R^4} \times 10^5 \times t^4 \times \frac{e(t)}{I}\right)^{1/3} \text{ siemens}$$

where

e(t)/I is in μV/A

t is in ms

R = half loop size in m

Hence if the thickness of the sheet is known, its conductivity can be calculated and vice versa. From e(t)/I data displayed for later times the extent and strike of conductors such as massive sulphide mineralization and graphitic schists can be estimated. Velikin & Bulgakov give rules for interpreting anomalies due to dipping tabular bodies, cylinders, and spheres.

The use of data obtained from different loop sizes assists interpretation. Larger loops will in general be more responsive to conductors at a greater depth and wider lateral extent than smaller loops. Accordingly large loops are primarily used in a reconnaissance mode. Areas of interest are resurveyed using smaller loops to provide more detail of selected anomalies. As a rule-of-thumb system, depth penetration can be considered roughly equal to the length of one side of a square loop. Unfortunately with the power unit supplied with the MPPO-1 equipment the depth penetration using a 200-m loop is probably no greater than that with a 100-m loop. This is due to the primary current pulse in the former loop being half that of the latter, thereby reducing the energizing field.

The use of loop-overlap in anomalous areas is recommended to assist quantitative interpretation by better defining the shape of an anomaly. But since the present survey was basically an instrument-evaluation survey and the main objective was to work in as many areas as possible in the available time, loop overlap was not employed.

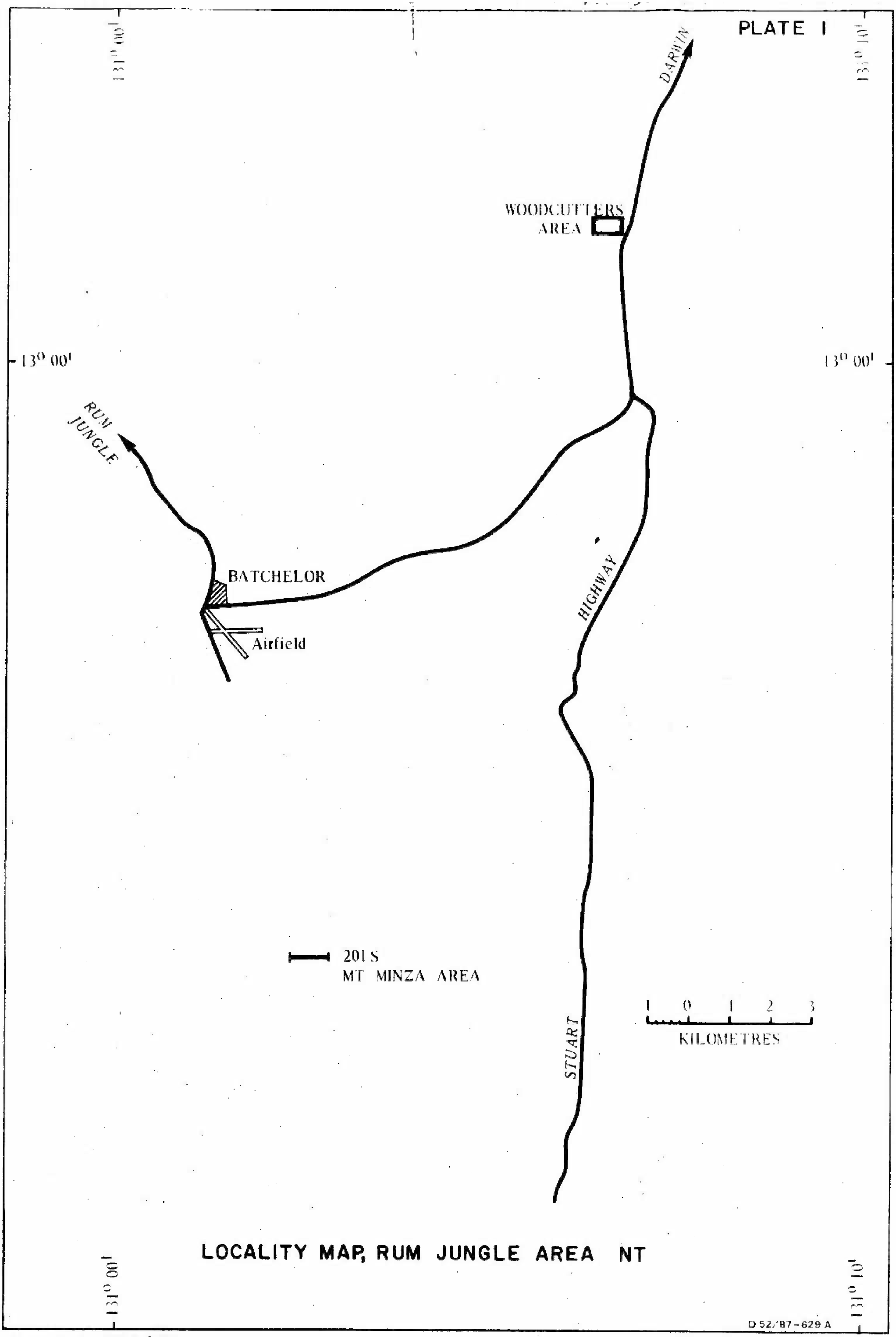
4. RESULTS FROM RUM JUNGLE

Surveys were conducted in the Mount Minza area and at the Woodcutters L5 Prospect (Plate 1).

Geology

The geology of the Katherine/Darwin area, which includes areas covered in the present survey, has been described by Walpole et al. (1968).

The rocks of the Mount Minza and Woodcutters areas are predominantly of the Lower Proterozoic Golden Dyke Formation. The dominant lithologies are dolomitic and carbonaceous siltstone, quartz siltstone, chert, and dolomite. The carbonaceous siltstone is in part pyritic. The formation is intruded in placed by amphibolite.



LOCALITY MAP, RUM JUNGLE AREA NT

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Most of the known mineralization in the Rum Jungle district is localized close to the contact between the Golden Dyke Formation and the underlying Coomalie Dolomite.

At Mount Minza, carbonaceous and graphitic shale is fairly well exposed but is strongly leached and silicified at the surface.

The Woodcutters L5 Prospect contains a complex Pb-Ag-Zn sulphide lode in an environment of carbonaceous and pyritic slate. This lode extends from about 100 metres to at least 200 metres below the surface. Geophysical logging of diamond-drill holes has shown that the slate is highly conductive and that differences in conductivity between the slate and highgrade mineralization are small. A north-striking anticline runs through the area.

Mount Minza Area

Previous geophysical surveys in the Mount Minza area located a zone of unusually high conductivity. This was first described by Shatwell & Duckworth (1966) following a Slingram, Turam, and radioactive survey. Follow-up surveys by Farrow (1967) and Duckworth (1968) involved further Turan surveys, as well as self-potential and induced polarization surveys.

All methods applied revealed strong anomalies over a highly conductive shale bed as shown in Plate 2. This bed is a graphitic, pyritic shale and is oxidized to a depth of about 15 metres. Slingram depth probes by Duckworth indicate that the top of the conducting body coincides with the intersection of the black shale and the base of oxidation. It is possible that sulphide mineralization exists in these shales below the zone of oxidation and that this, combined with the graphite, produces exceptionally high conductivity. Laboratory measurements show that the black shale has conductivities greater than 0.1 siemens/m.

The T.E.M. survey consisted of one traverse, with loops centred on 200S (base of loop on 201S). The results shown in Plate 3 indicate a strong anomaly associated with the conducting shale bed. The transient decay curve lasts for all sample times, indicating a strong conductor.

From the $\tau(t)$ curve it can be seen that τ_o is about 6.3 ms. The asymmetry of the anomaly reflects the dip of the bed. The profile for 1.1 ms peaks at 447 E, whereas for late sample times the maximum anomaly occurs farther to the west at 445 E. The anomaly at early sample times is due to the less-conductive weathered near-surface shale and upper parts of the unweathered conductive shale bed. At later sample times it is caused by the deeper, more conductive section of the shale bed. Therefore by examining the shape of the profiles at different sample times it is possible to infer the westerly dip of the body.

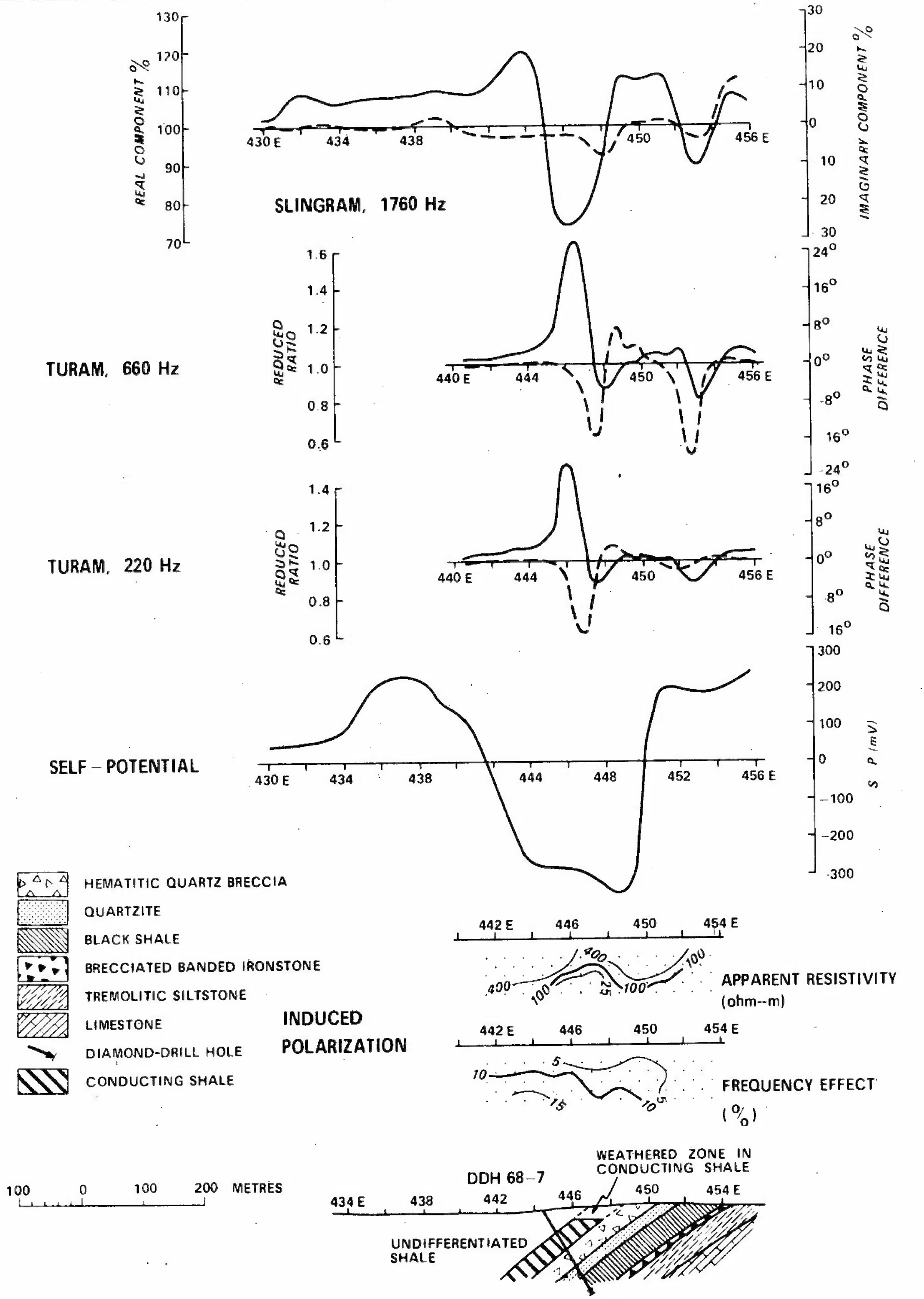
Woodcutters L5 Prospect

In 1964, reconnaissance geological, geophysical, and geochemical surveys in the Rum Jungle area outlined a broad anomalous area called the Woodcutters area (Dodson & Shatwell, 1965; Duckworth, 1966a). In 1965 Shatwell's detailed geochemical work, outlined several anomalous lead areas, one of which was termed L5 (Shatwell, 1966).

Drilling commenced in 1965 and subsequently outlined the sulphide lode referred to earlier. Duckworth, in a detailed Slingram survey in the area (Duckworth, 1966b) recorded high real components over most of the area. Comparison of field data with model experiments indicated the presence of a horizontal conductor at a depth of approximately 50 m which was presumed to be the top of the unweathered black shale.

In 1966, Turam, self-potential, induced polarization, and gravity surveys were carried out to determine whether any of these methods could be used to detect orebodies of the L5 type situated in a zone of deep weathering (Duckworth, Farrow & Gardener, 1968; Gardener, 1968). The Turam results were interpreted as indicating an extensive horizontal conductor at depth. Variations in the Turam profile were related to variations in the depth of weathering of the conductive slate. The induced polarization results showed a marked decrease in apparent resistivity with increasing dipole spacing. Values greater than 250 ohm-m were recorded near the surface but decreased to less than 10 ohm-m at larger dipole separations. There was also a tendency for lower apparent resistivities values to be recorded closer to the surface at the western end of the profiles, which was attributed to a decrease in the depth of weathering.

The gravity results outlined five main anomalies, one of which occurs just south of the area dealt with in the present survey. The position of this anomaly (Anomaly B) corresponds to the position of an elevated unweathered feature described by Duckworth following his Slingram depth-probe tests. The anomaly has a northerly strike, and could thus extend into the area shown in Plate 4. According to Duckworth there is a decrease in the depth of weathering to the west of 36 E, the minimum depth being at about 31 E.



RUM JUNGLE, MT MINZA AREA, TRAVERSE 201 S
COMPARISON OF GEOPHYSICAL METHODS

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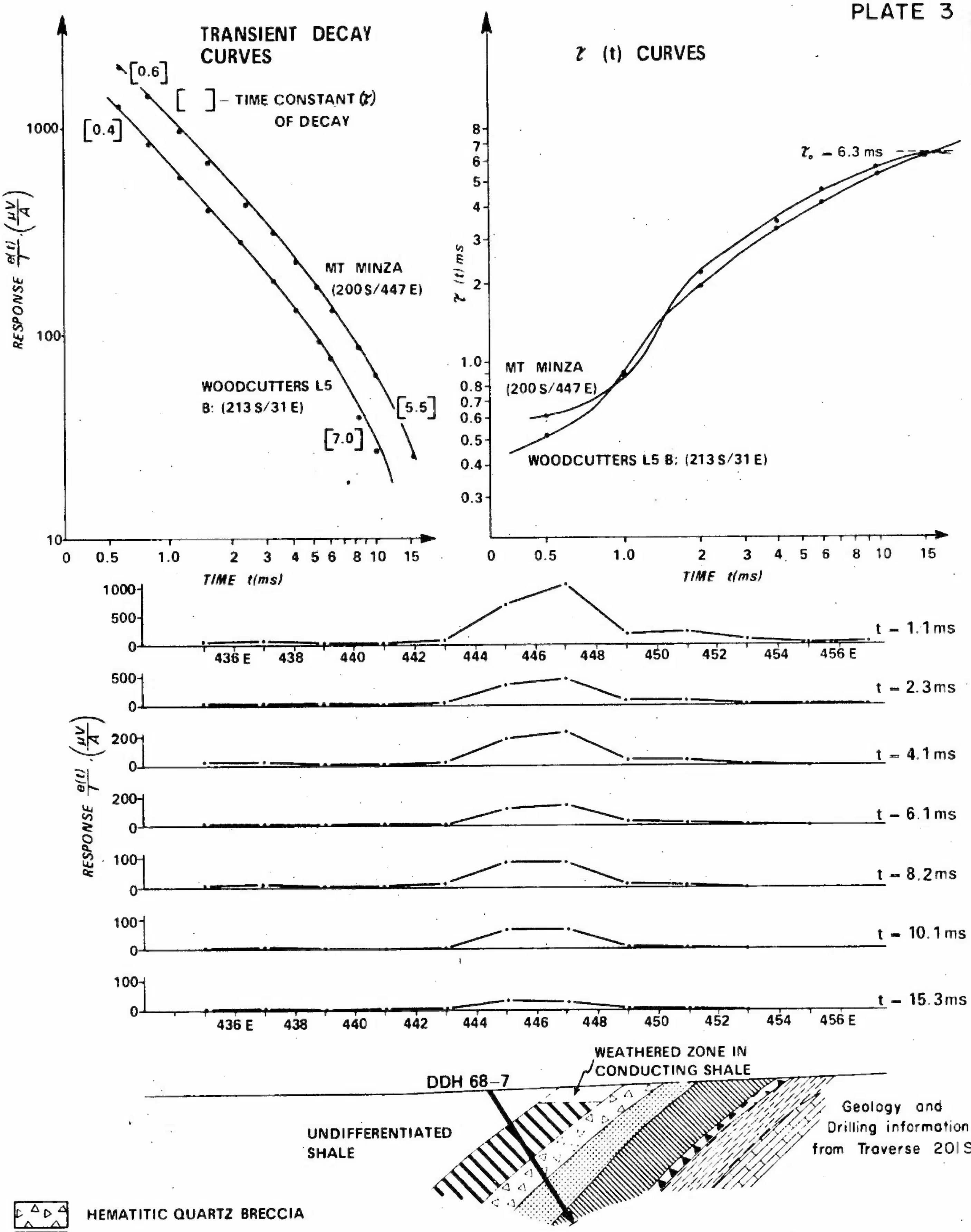
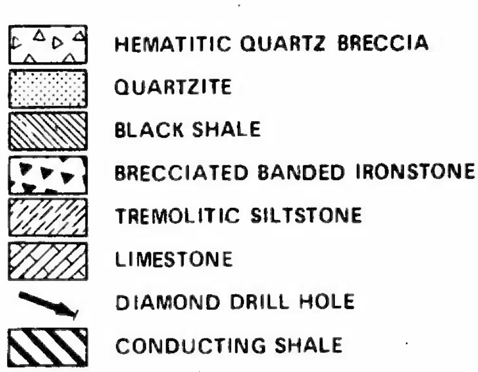
PLATE 3





RUM JUNGLE, MT MINZA AREA TRAVERSE 200 S PROFILES OF $\frac{e(t)}{I}$ AND GEOLOGICAL SECTION (after Duckworth, 1968) (60m LOOPS)

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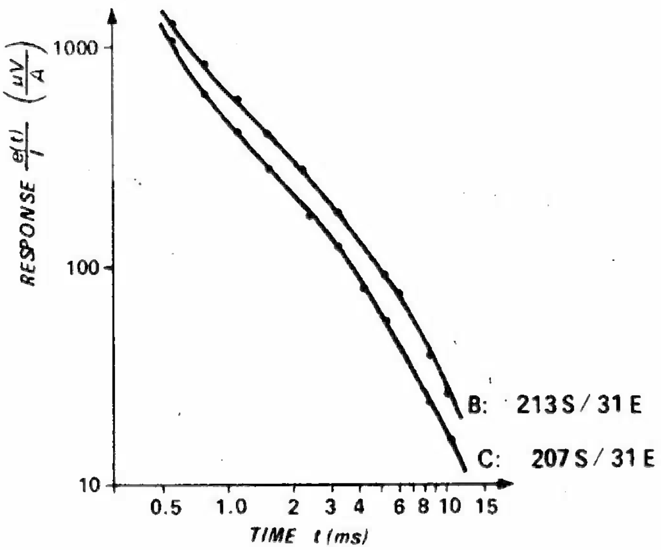
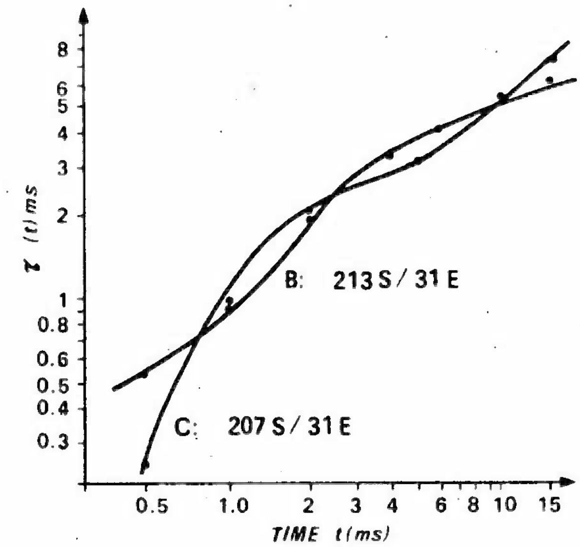
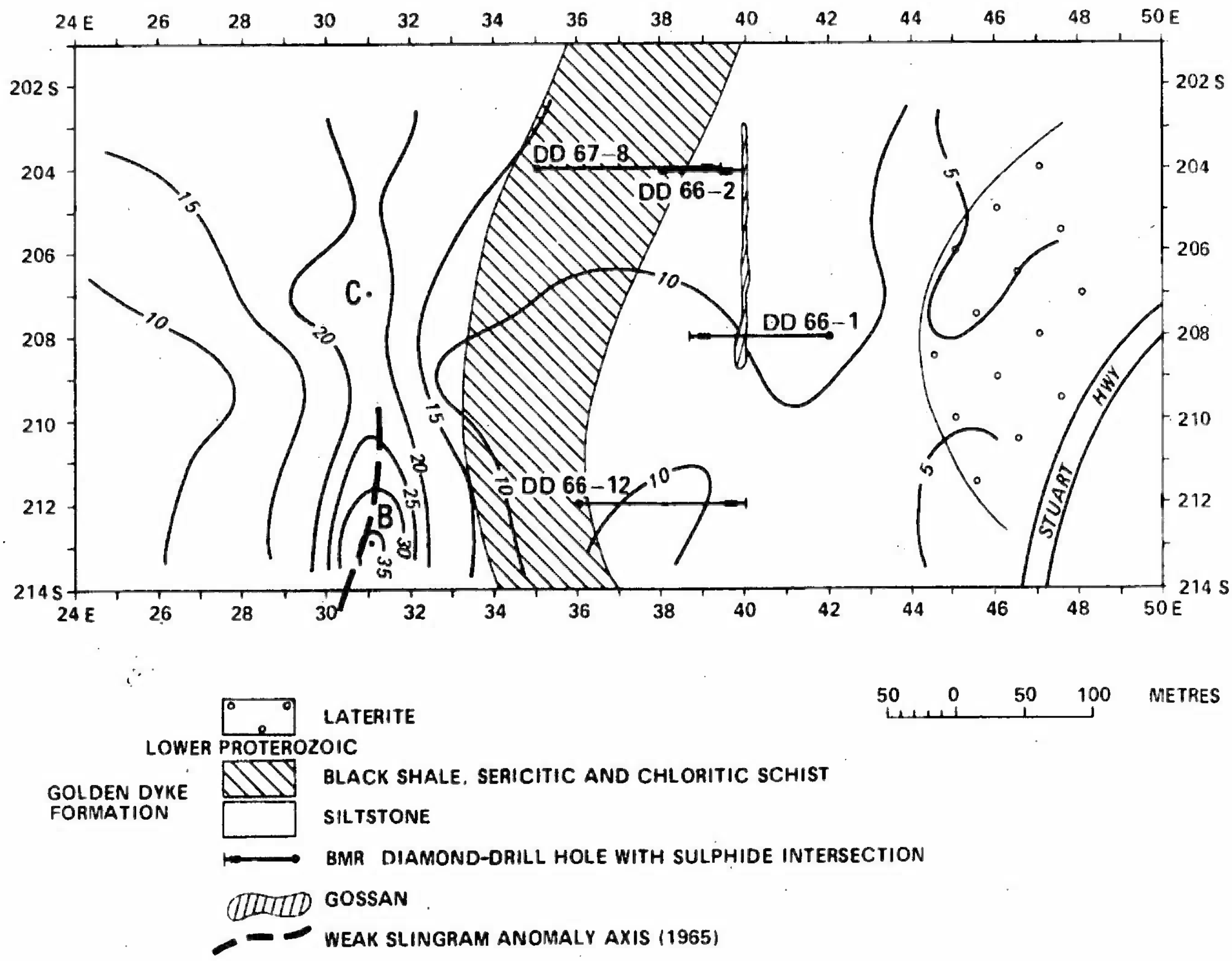
TRANSIENT DECAY CURVES



τ (t) CURVES





RUM JUNGLE, WOODCUTTERS L5 AREA

CONTOURS OF $\frac{e(t)}{I}$ IN $\frac{\mu V}{A}$ FOR $t = 8{\cdot}2$ ms (60m LOOPS)

Plate 4 shows a contour map of T.E.M. results obtained from the present survey. A north-striking anomaly at 31 E decreases in magnitude towards the north. Transient decay curves at the centre of the anomaly (point B) and along the anomaly axis farther north (point C) are also shown. The curves are similar in shape except at very early times, when the maximum response is from near-surface features. Comparing transient decay curves for Woodcutters and the Mount Minza shales it is apparent that they are very similar, having large time constants, $\tau_0 = 6$ ms, for later sample times. The body causing the anomaly at Woodcutters is obviously the highly conductive black shale which gives large responses with other E.M. methods.

The position of the T.E.M. anomaly coincides with the Slingram and gravity anomalies mentioned above. The common source is a 'high' in the unweathered bedrock which plunges towards the north. No anomaly was obtained over the sulphide mineralization because of the lack of conductivity contrast between the mineralization and country rock.

5. RESULTS, TENNANT CREEK

Surveys were carried out in Area C6, Area C11 (Anomaly C11 and C12), and BMR Area No. 3. (Plate 5).

Geology

The area contains Lower Proterozoic greywacke and shale of the Warramunga Group, intruded by quartz-feldspar porphyry and containing lodes of ironstone. These ironstones are mostly quartz-magnetite bodies below the water-table but have been changed either partly or completely to hematite in the oxidized zone. Most of the known copper or gold orebodies occur within, or in close association with, the ironstone lodes, whose origin is not entirely clear. In general the emplacement of ironstones appears to have been controlled by the intersection of favourable lithology and structural features such as shear zones and drag folds.

The maximum topographic relief in the area is about 100 metres. Most of the low-lying areas are occupied by alluvium, creek gravel, and aeolian deposits. The thickness of these deposits averages 2 metres and is rarely greater than 8 metres. The depth of oxidation usually exceeds 70 metres.

For more detailed summaries of the geology of the Tennant Creek field the reader is referred to reports by Shelly and Brown-Cooper (1967) and Finney (1967).

Previous geophysical surveys

Pioneer ground magnetic surveys were done by the Aerial, Geological and Geophysical Survey of Northern Australia in 1935-37. In 1956, BMR carried out an airborne magnetic and radiometric survey as part of a program to cover the Tennant Creek Mineral Field. In 1960 the survey was extended to cover the entire Tennant Creek 1:250 000 Sheet area. These surveys indicated a very pronounced pattern of regional anomalies which reflected major shear zones, as well as numerous local anomalies produced by ironstone bodies. Since 1960 a large number of geophysical investigations have been made by the Australian Government and by private companies. By far the most successful method applied has been the magnetic method, because of the association of gold and copper mineralization with certain ironstone bodies. The reader is referred to reports by Haigh (1969) and Hone (1974) for details of typical BMR ground magnetic surveys completed in recent years.

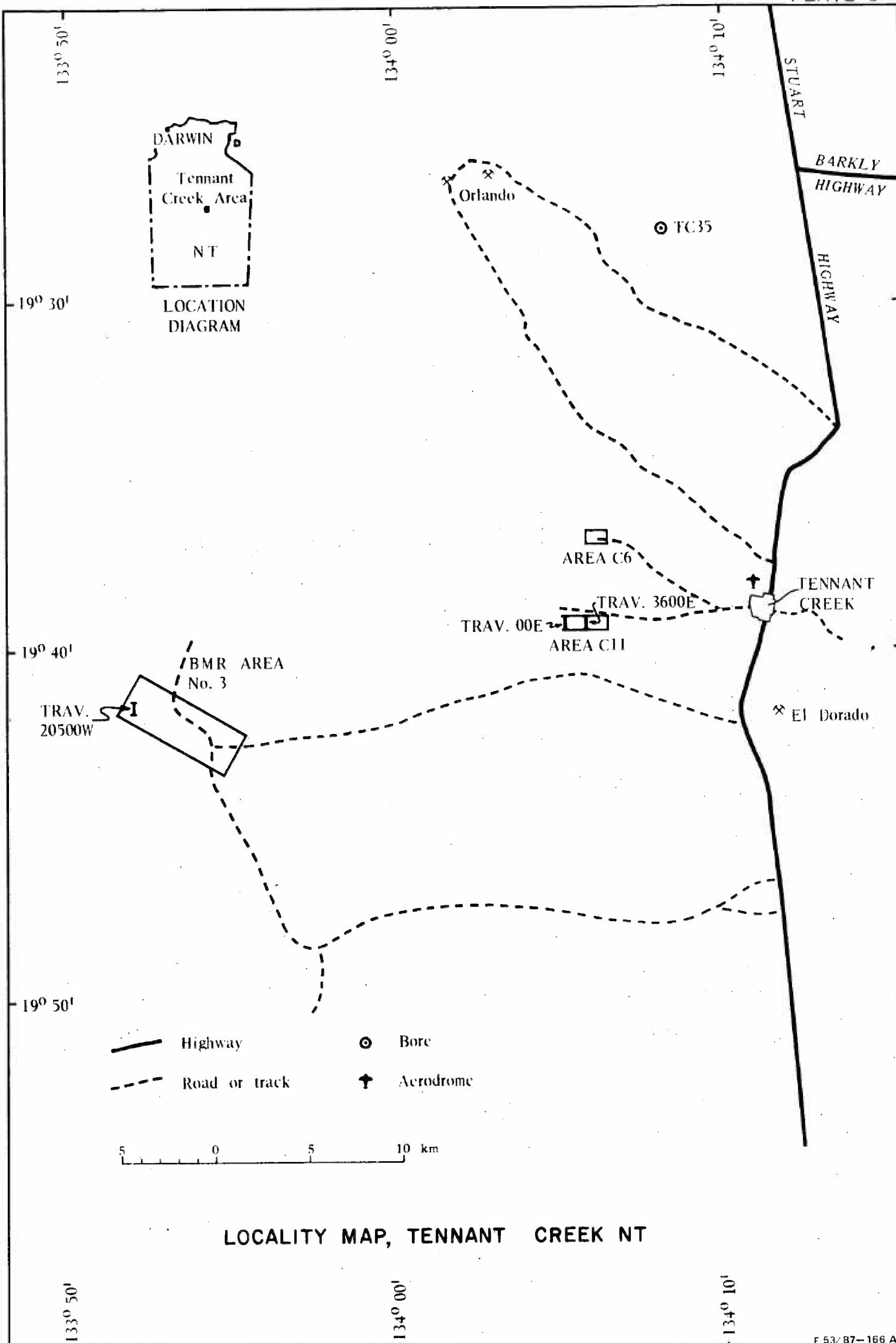
Area C6

This area is situated on a low ridge of Warramunga Group sediments which mostly comprise shale, siltstone, and greywacke. The ridge has a core of quartz-feldspar porphyry. Minor ironstone bodies crop out within the sediments. The prophyry and sediments adjacent to the ironstone bodies are strongly sheared, the shear zone striking roughly east-west through the area. The depth of oxidation exceeds 85 m.

Drilling and magnetic data indicate that the main ironstone body is probably near-vertical and pipe-like, approaching to within 40 m of the surface (Hone, 1974).

A contour map of e(1.1)/I is presented in Plate 6. The main feature displayed is an elongated anomaly striking 075° which coincides with the shear zone mentioned above. Readings at all stations have decayed to zero by $t = 3$ ms and have a single time constant, τ , of about 0.33 ms. This response is typical of a horizontal conductor and could be due to conductive surficial deposits, zones of saline water, or the conductive oxidized zone as a whole. By making use of the concept 'lateral conductivity', S, a value is obtainable for the product of conductivity and thickness of the layer. Assuming that the conductive layer represents the zone of oxidation with thickness, d,

PLATE 5



LOCALITY MAP, TENNANT CREEK NT

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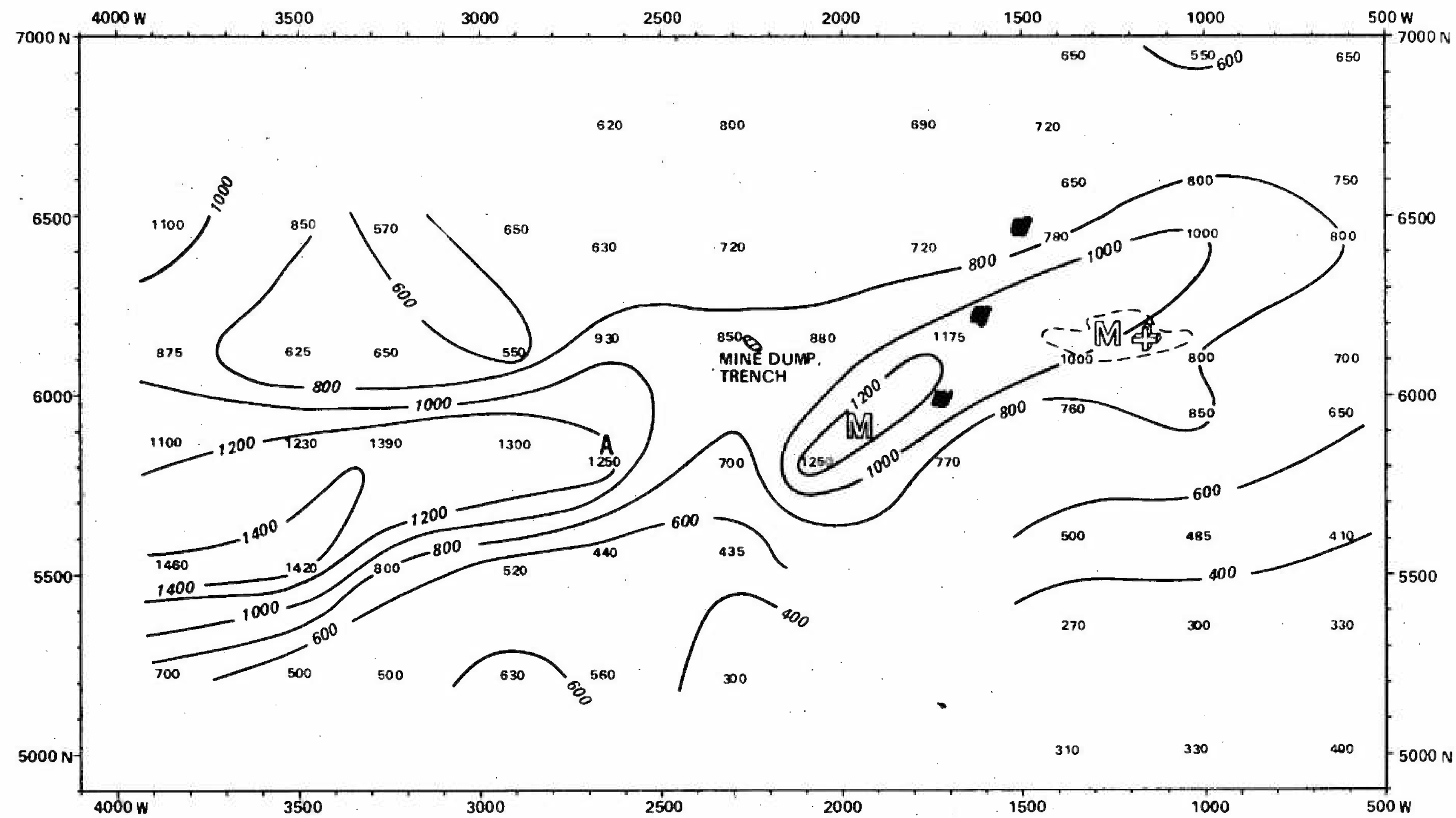

LEGEND

OUTCROP OF IRONSTONE

SURFACE PROJECTION OF IRONSTONE BODY, (after Daly and Willis, 1972)

MAGNETIC GRADIENT ANOMALY (after Hone, 1974)

GRAVITY ANOMALY

50 0 50 100 150 200 METRES

TENNANT CREEK, AREA C6

CONTOURS OF $\frac{e(t)}{I}$ IN $\frac{\mu V}{A}$ FOR t = 1·1ms

(100m LOOPS)

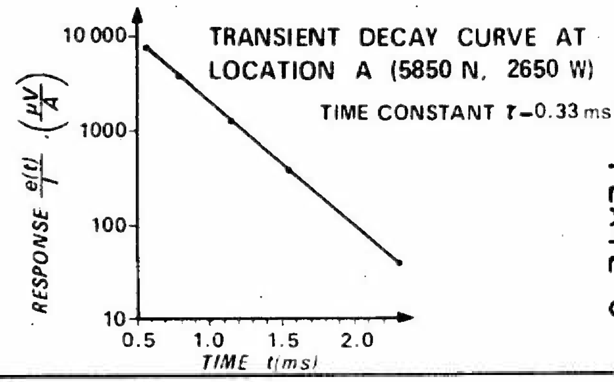

PLATE 6

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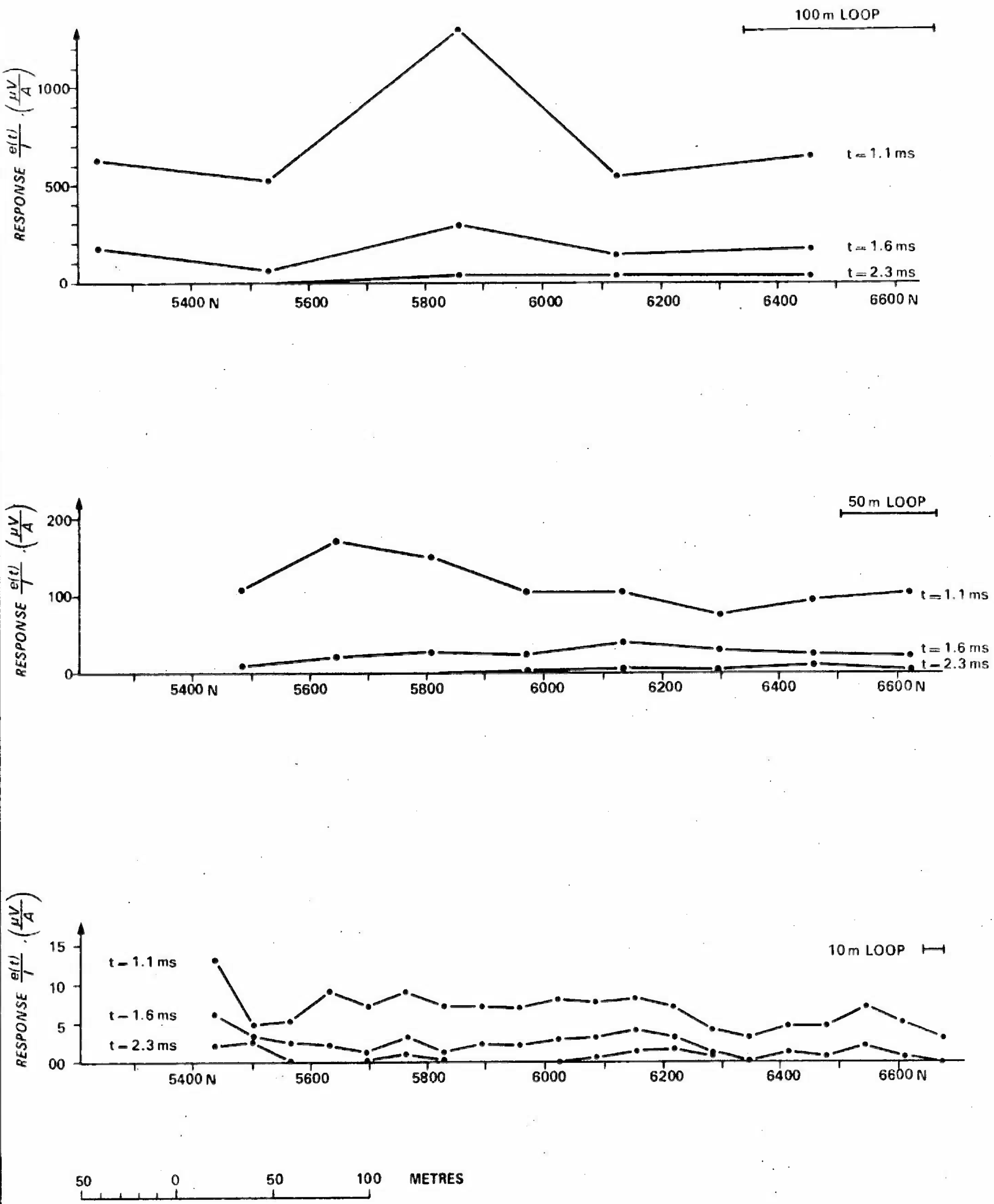
PLATE 7



TENNANT CREEK, AREA C6

TRAVERSE 2900 W

PROFILES OF $\frac{e(t)}{I}$ WITH LOOPS OF DIFFERENT SIZE equal to 85 m, its resistivity would range from 15 to 26 ohm-m, being a minimum at the centre of the anomaly. Conversely, assuming a constant resistivity of 20 ohm-m, the thickness would range from 66 m to 112 m. Probably regions of lower resistivity and deeper weathering coincide as a result of decomposition of rocks in the brecciated shear zone.

North-south profiles for loops of different sizes along traverse 2900 W are shown in Plate 7. The 10 m loop profile is basically featureless whereas larger loops reveal an anomaly between 5600 N and 5800 N. This indicates that the depth of investigation of the 10 m loop is insufficient for it to respond to the anomaly source, which appears to be associated with the deeper parts of the shear zone. It is apparent from the surface projection of the main ironstone body outlined on the contour map that this lies within the anomalous zone. But no distinctive response was obtained over the body itself, which suggests that the conductivity of the ironstone is low, a hypothesis in keeping with laboratory conductivity measurements of typical ironstones from Tennant Creek.

Area C11

Anomaly C11. Extensive wagon-drilling carried out by the Mines Branch of the Northern Territory Administration near 1200 N/150 W in Area C11 has shown that a quartz-magnetite-hematite body reaches to within 2 to 8 m of the surface, and extends to a depth of at least 70 m. The sheared nature of the surrounding sedimentary rocks indicates that the ironstone was emplaced in an east-striking shear.

Profiles of e(t)/I obtained along Traverse 150 W are presented in Plate 8 and show a low over the body with peaks on either side. Time characteristics of the transient decay at stations 1350 N and 1950 N are shown in Plate 9 (curves B and C), and have been transposed by parallel vertical transfer to enable time constants to be compared. It can be seen that the time constants are similar both near and away from the body.

Double-peaked anomalies can be obtained over bodies lying at shallow depth, the distance between peaks being equal to the size of the loop (Velikin & Bulgakov, 1967). However, in Area C11 the distance between the peaks is 600 m and the loop size is 100 m. It is therefore probable that the peaks reflect differences in thickness and/or conductivity of the overburden. Taking a value of 90 m for the thickness of the oxidized zone, its resistivity would range from 30 to 40 ohm-m along the profile. Laboratory tests on samples from Tennant Creek suggest that the ironstone is likely to have a resistivity higher than this. Hence the low readings over the ironstone body are interpreted as being due to thinning of the overburden.

Anomaly C12. This anomaly is situated about 1200 metres east of Anomaly C11 in an area where extensive deposits of sand and silt cover sandstone and slate of the Warramunga Group. Magnetic characteristics indicate that porphyry may underlie much of the covered area immediately to the north. A drill-hole put down by the Mines Branch intersected a total of 20 m of disseminated magnetite and some disseminated chalcopyrite (averaging 0.4% Cu) at a depth of about 180 m, so the ironstone at C12 is probably more conductive than that at C11. This drilling established the base of oxidation to be at 93 m.

Profiles of e(t)/I are shown in Plate 10. At early sample times there are two broad anomalies, centred at 600 N and 1800 N. At later sample times the more southerly anomaly decays faster than the northern anomaly. This is clearly seen in Plate 9, which shows the anomaly decay characteristics at stations 650 N and 1850 N. At station 650 N the decay curve time constant, τ, ranges from 0.21 to 0.35 ms, whereas at 1850 N it ranges from 0.35 to 0.92 ms. The larger value obtained at later sample times at 1850 N indicates the presence of a conductive body. However since the response decays to zero by 5 ms the conductivity cannot be high.

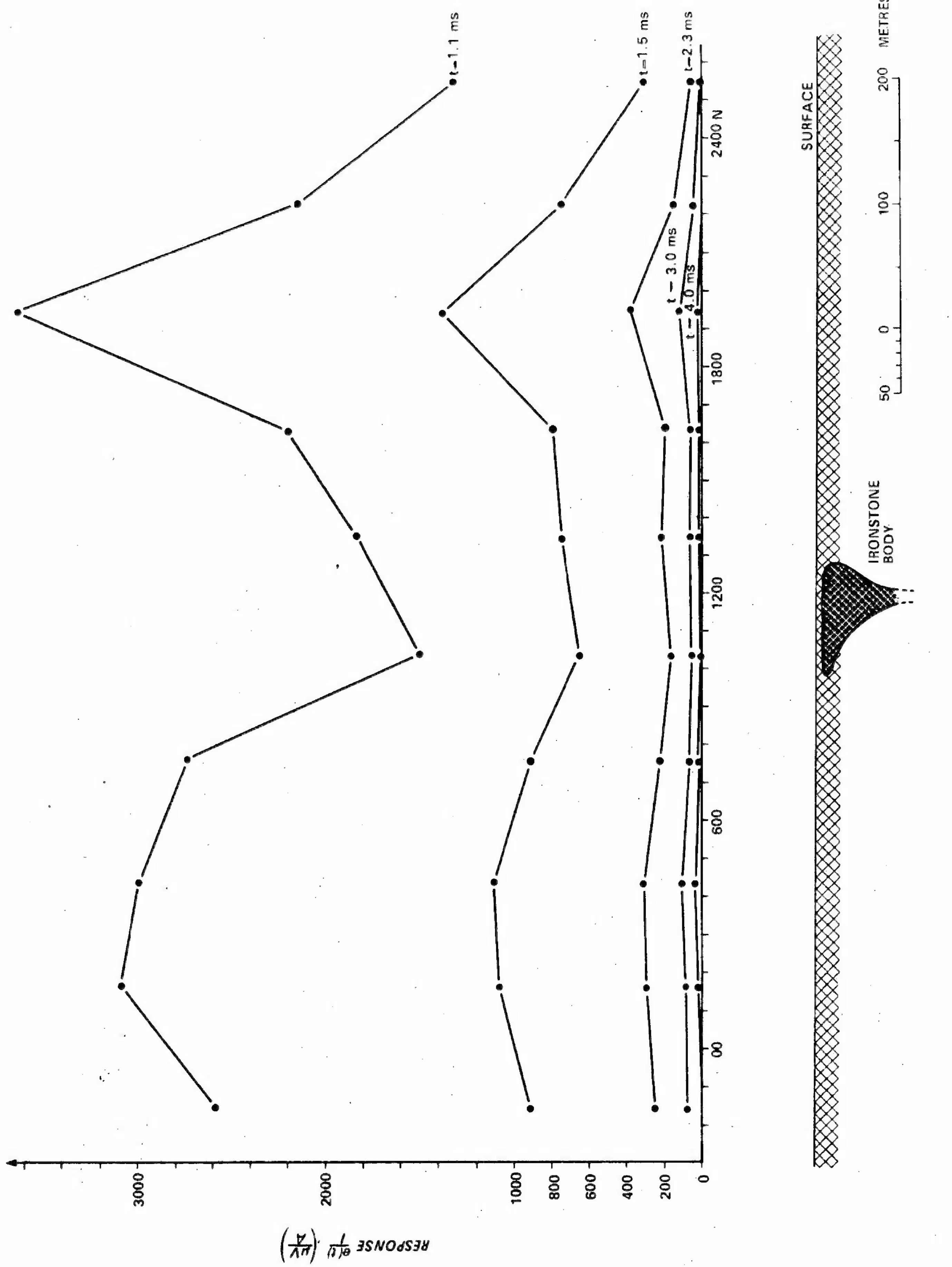
The anomaly at 1850 N may be due to near-surface extensions of the mineralization intersected by drilling, a hypotheses supported by a shallow-seated gravity anomaly reported at approximately 1800 N (Hone, 1974). The anomaly at 650 N is contrast probably caused by slightly thicker or more conductive overburden.

Farther to the north, at about 2500 N, very low values of e(t)/I were obtained. This indicates the presence of porphyry, assuming that this rock is much more resistive than the oxidized Warramunga sediments. A contact is interpreted at about 2400 N.

BMR Area No. 3

High-grade metamorphic gneisses and schists are overlain by sandy plains in this area. A drill hole put down by the Mines Branch to determine the source of a magnetic anomaly in this locality indicated the depth of oxidation to be 70 m, and intersected concentrations of up to 5% pyrite and 10% graphite between 90 and 170 m. Beyond 170 m the gneiss became iron-rich, containing

PLATE 8



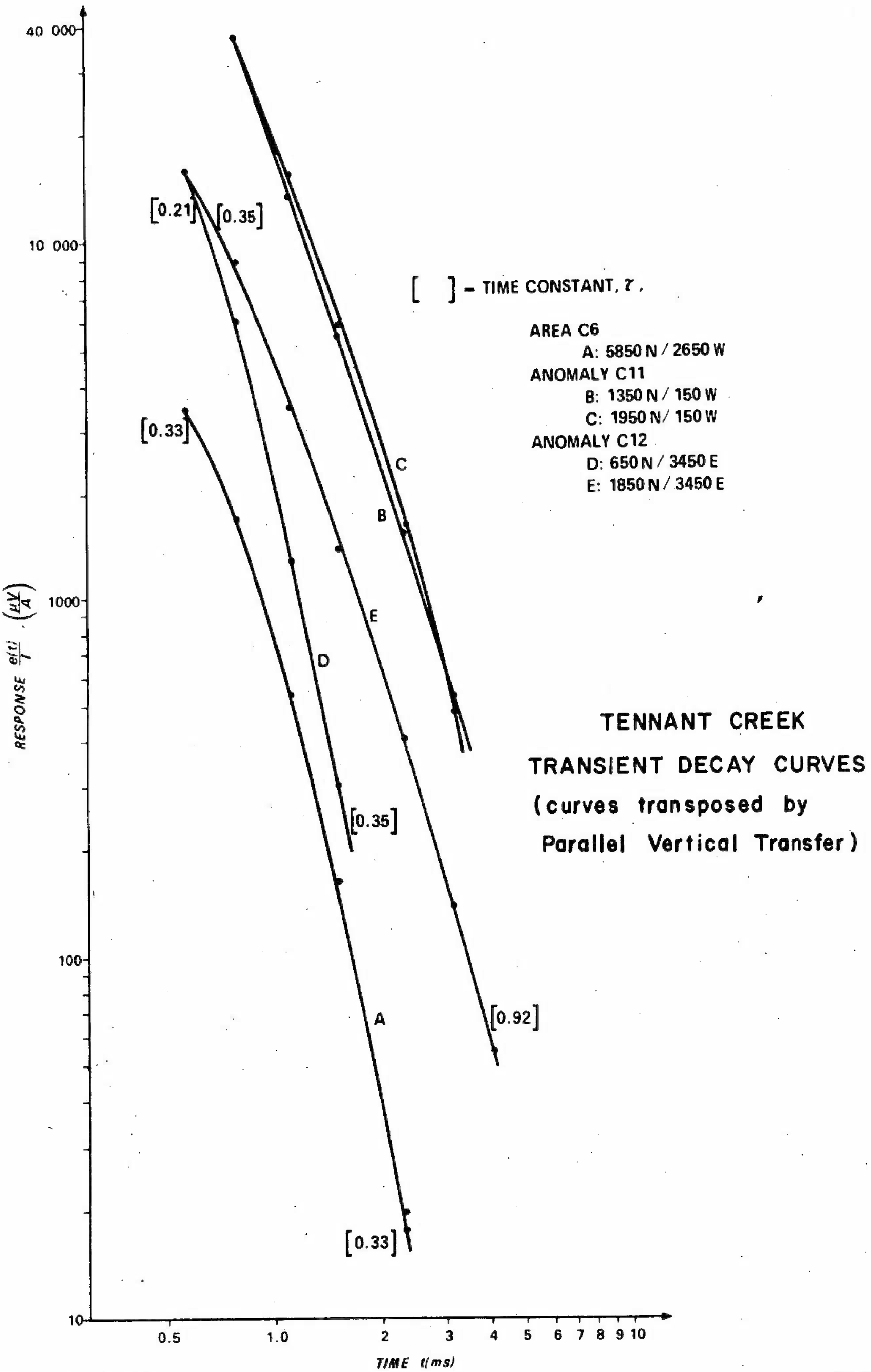
TENNANT CREEK, AREA C II TRAVERSE 150 W

PROFILES OF $\frac{e(t)}{I}$ AND CROSS-SECTION OF IRONSTONE BODY

(100m LOOPS)

Record No. 1974/167

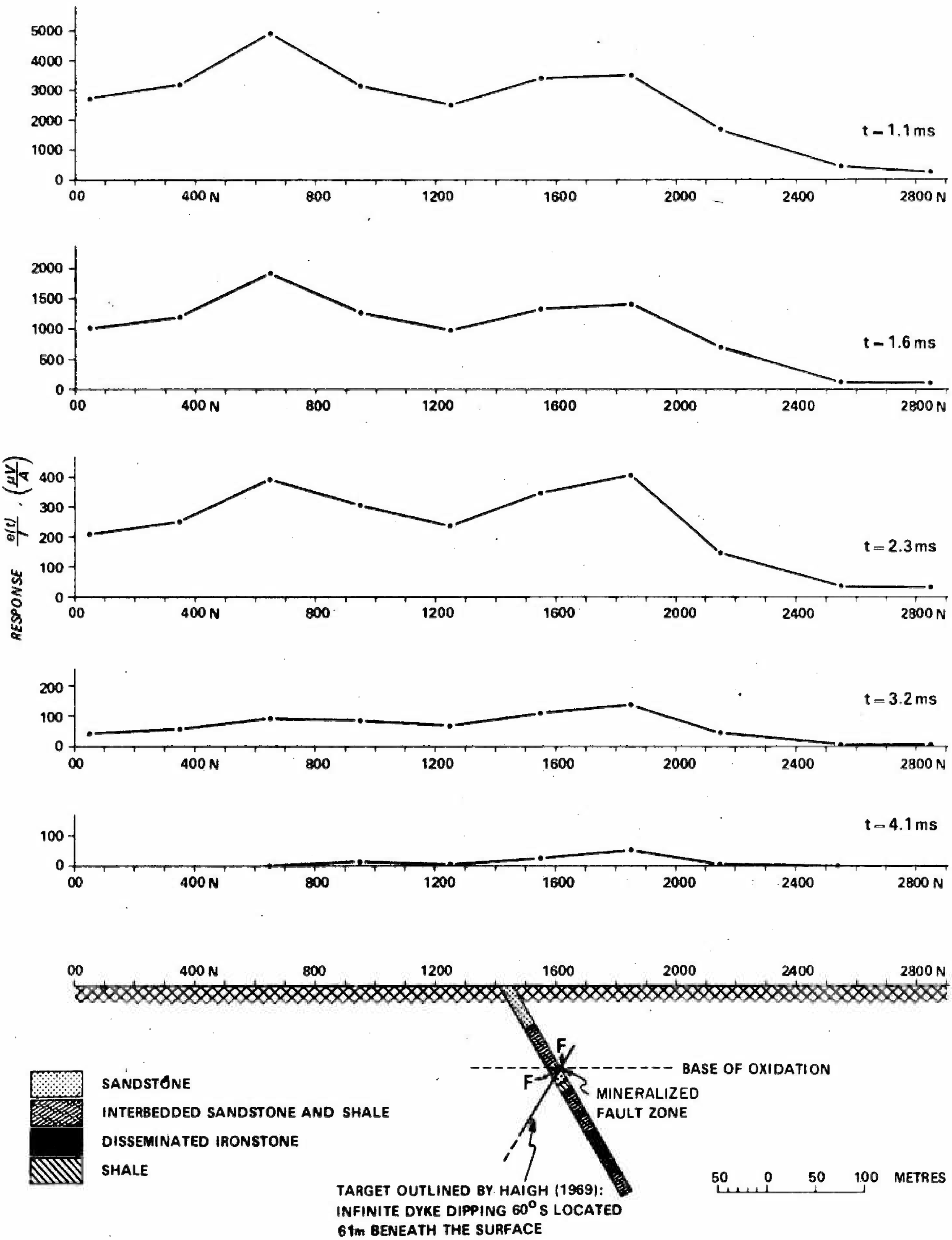
E53/B7-162 A



40 000
10 000
1000
100
10
RESPONSE $\frac{e(t)}{I}$, $\left(\frac{\mu V}{A}\right)$
0.5
1.0
2
3
4
5
6
7
8
9
10
TIME t(ms)
[0.21]
[0.35]
[0.33]
[0.35]
[0.92]
[0.33]
A
B
C
D
E
[ ] - TIME CONSTANT, τ .
AREA C6
A: 5850 N / 2650 W
ANOMALY C11
B: 1350 N / 150 W
C: 1950 N / 150 W
ANOMALY C12
D: 650 N / 3450 E
E: 1850 N / 3450 E
TENNANT CREEK
TRANSIENT DECAY CURVES
(curves transposed by
Parallel Vertical Transfer)

E 53/B7 - 163 A

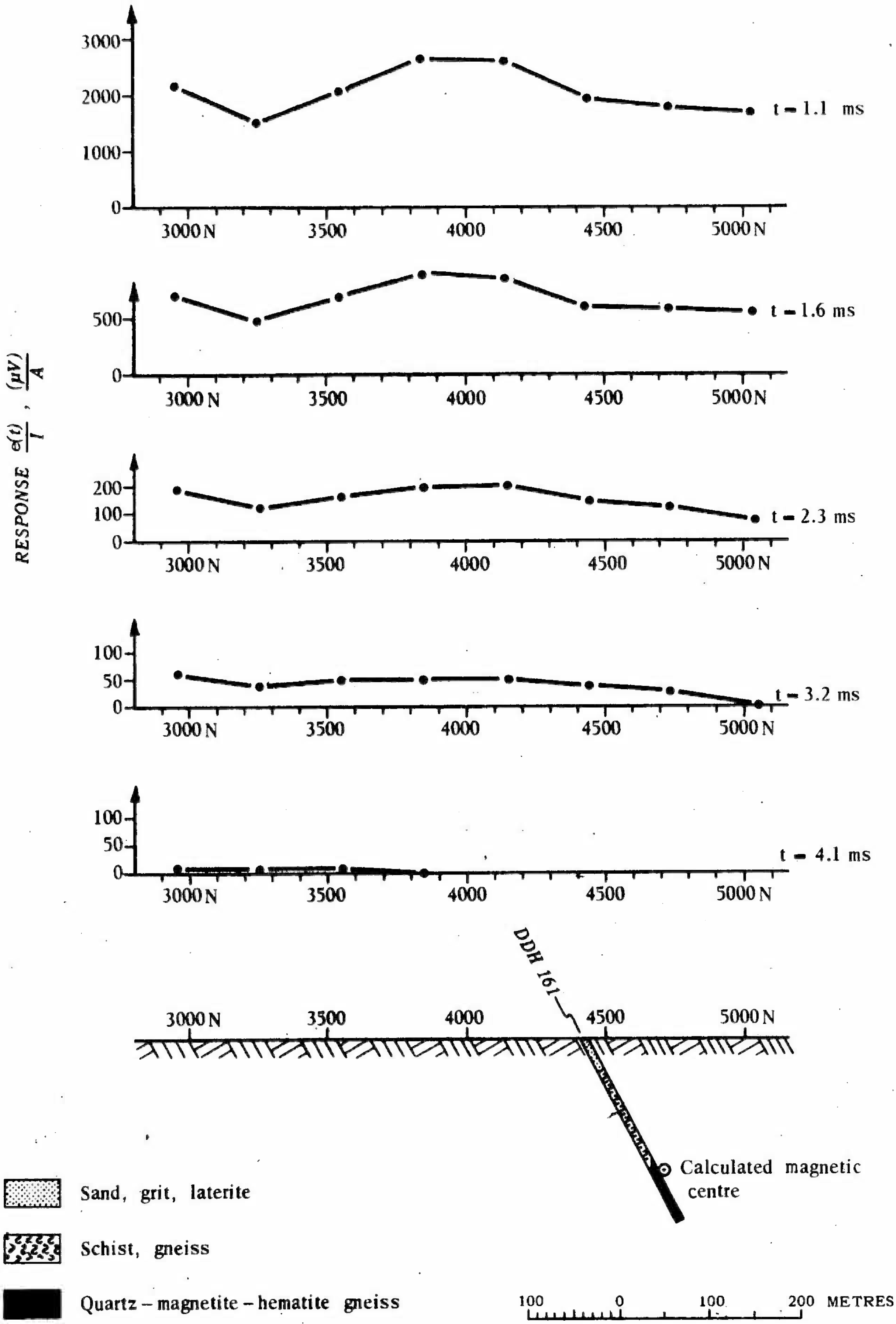
PLATE 10



TENNANT CREEK, AREA C11 (ANOMALY C12) TRAVERSE 3450 E
PROFILES OF $\frac{e(t)}{I}$ AND DRILLING INFORMATION (after Daly, 1970)
(100 m LOOPS)

E53/B7-164 A

Record No. 1974/167



TENNANT CREEK, BMR AREA No. 3 TRAVERSE 20350 W

PROFILES OF $\frac{e(t)}{I}$ AND DRILLING INFORMATION

(TRAV 205 W, After William, 1969, Unpub.)

E 53/87—165 A

up to 5% magnetite and 20% hematite.

Plate 11 shows e(t)/I profiles over the drill-hole referred to above from which it is evident that no rock unit intersected produces a diagnostic response at the surface.

The transient decay is exponential with a time constant, τ, of 0.6 ms indicative of the large response at early times being due to conductive surface layers.

6. RESULTS, CLONCURRY

Test surveys were carried out in the Red Sierra South, Celestial, Dawn, and Timberu areas south and west of Cloncurry as shown in Plate 12.

Regional geology

The areas surveyed lie within the Marraba 1:100 000 Sheet area, the geology of which has been described by Derrick et al. (1971). Further geology is given by Carter, Brooks & Walker (1961).

Proterozoic rocks occupy most of the Sheet area. The Dawn and the Celestial areas occur within the Marraba Volcanics, a sequence of mildly metamorphosed basalt, sandstone, siltstone, with minor limestone, agglomerate, and tuff. The Red Sierra area contains rocks belonging to the Marimo Slate, which is a sequence of sandy slate, quartz greywacke, and calc-silicate rocks. Carbonaceous and graphitic slates are locally well developed. Extensively deformed rocks of the lower Corella Formation are present in the Timberu area. These consist of a diverse sequence of carbonate-rich and calc-silicate granofels.

Red Sierra South area

The rocks in this area strike NNW. Siltstone, grey and buff phyllite, and minor interbedded fine-grained sandstone occur in the east. These rocks are flanked to the west by a 100 m thick sequence of black to grey shale which is locally carbonaceous and possibly calcareous. Thiis sequence is in turn bounded to the west by ridge-forming quartzite and slate. The topographic relief in the area is about 100 m. Two zones of mineralization are present. One, at the contact between the carbonaceous black shale and the grey to buff phyllite, contains the Red Sierra South mine (Plate 14). The other, located in the eastern phyllite and siltstone, extends eastwards from the black shale and contains the Great Western mine. Both 'mines' are only minor diggings, mineralization exposed being made up of scattered veins of malachite, azurite, chalcocite, and chrysocolla. No primary sulphides have been seen in the near-surface workings, but low-grade (0.5%) sulphide mineralization is reported to have been intersected by a diamone-drill hole at a depth of 100 m near the Red Sierra South mine.

A comparison of T.E.M. and S-P data from Traverse 150 N and 180 N respectively is shown in Plate 13. Similar changes, evident in both the S-P and T.E.M. responses across the black shale, are probably related to variations in graphite content and weathering. The extension of the T.E.M. anomaly some 50 m either side of the black shale is due to the finite size of the loop used.

Results from an I.P. survey by Sampath & Ogilvy (1974) evidenced the conductive nature of the black shale. Apparent resistivities as low as 1 or 2 ohm-m and frequency effects up to 18% were recorded.

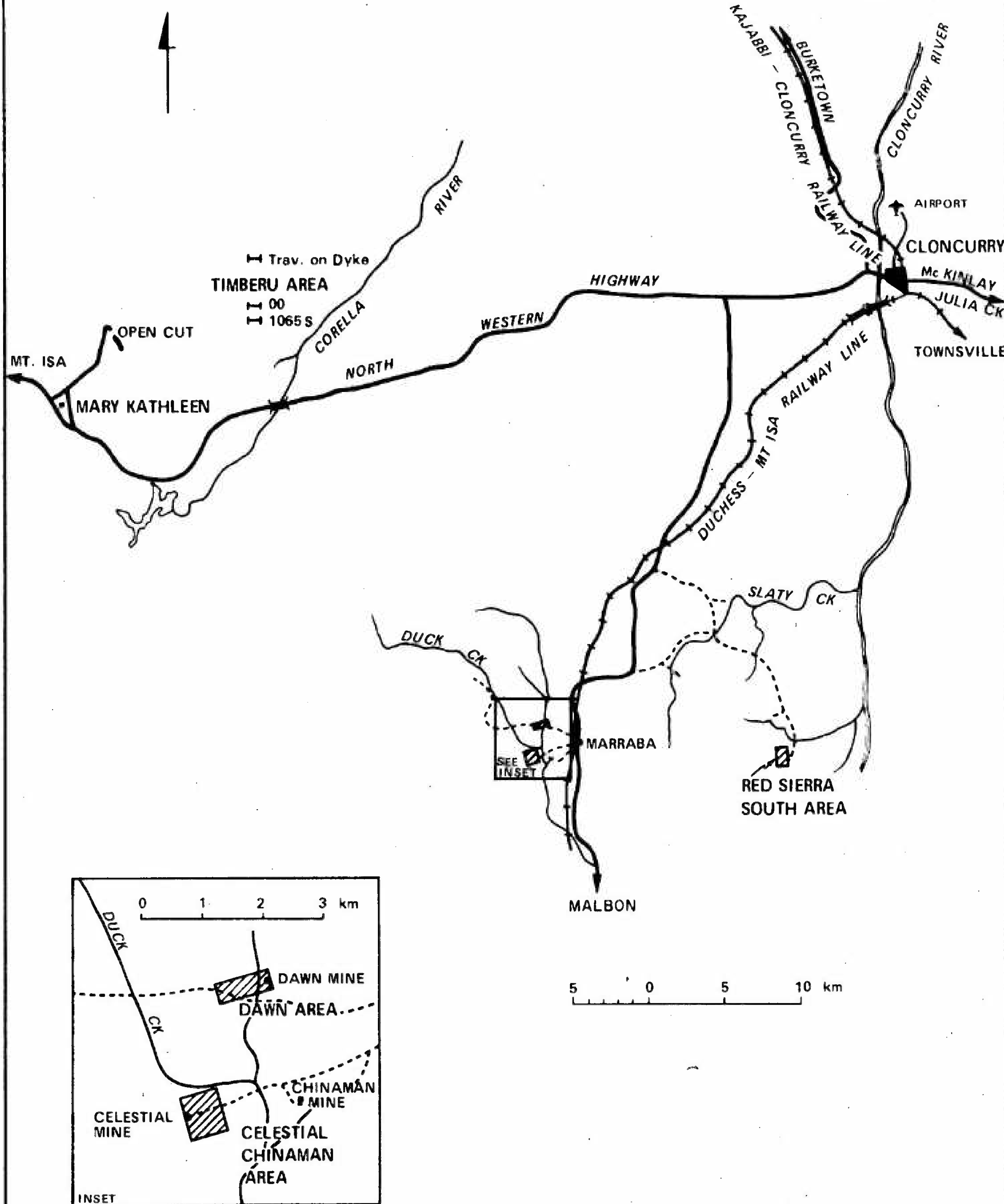
An attempt by the same workers to carry out a Turam survey in this area met with little success when the primary Turam loop was laid out to the east of 150 E, and readings were taken to the west. Readings were unobtainable over the black shale as current was apparently channelled along its eastern margin. In contrast to the Turam results, a good response is obtainable over the black shales with the T.E.M. method as evidenced by the contour map of e(t)/I response for 60 m loops at t= 1.1 ms shown in Plate 14. Transient decay curves produced from different locations A, B, and C within the black shale are shown in Plate 15. The similarity of these curves for points A and C indicates that if sulphides are present at the latter point, the loop layout for which includes the Red Sierra South mine, then there is no T.E.M. parameter to distinguish their response from that due to the black shales alone. Minor dissimilarities between the curve for point B and those for A and C at the early sample times are probably related to local changes in the graphite content of the black shale and in weathering effects.

At 60 E/150 N the e(t)/I response decayed from 45 μV at t = 1.1 ms to zero by 2 ms (curve D). This decay has a very small time constant and is probably due to alluvial cover. Alluvium is not present to the west of 300 W, where values of e(t)/I at 1 ms are less than 10 μV.

Celestial area

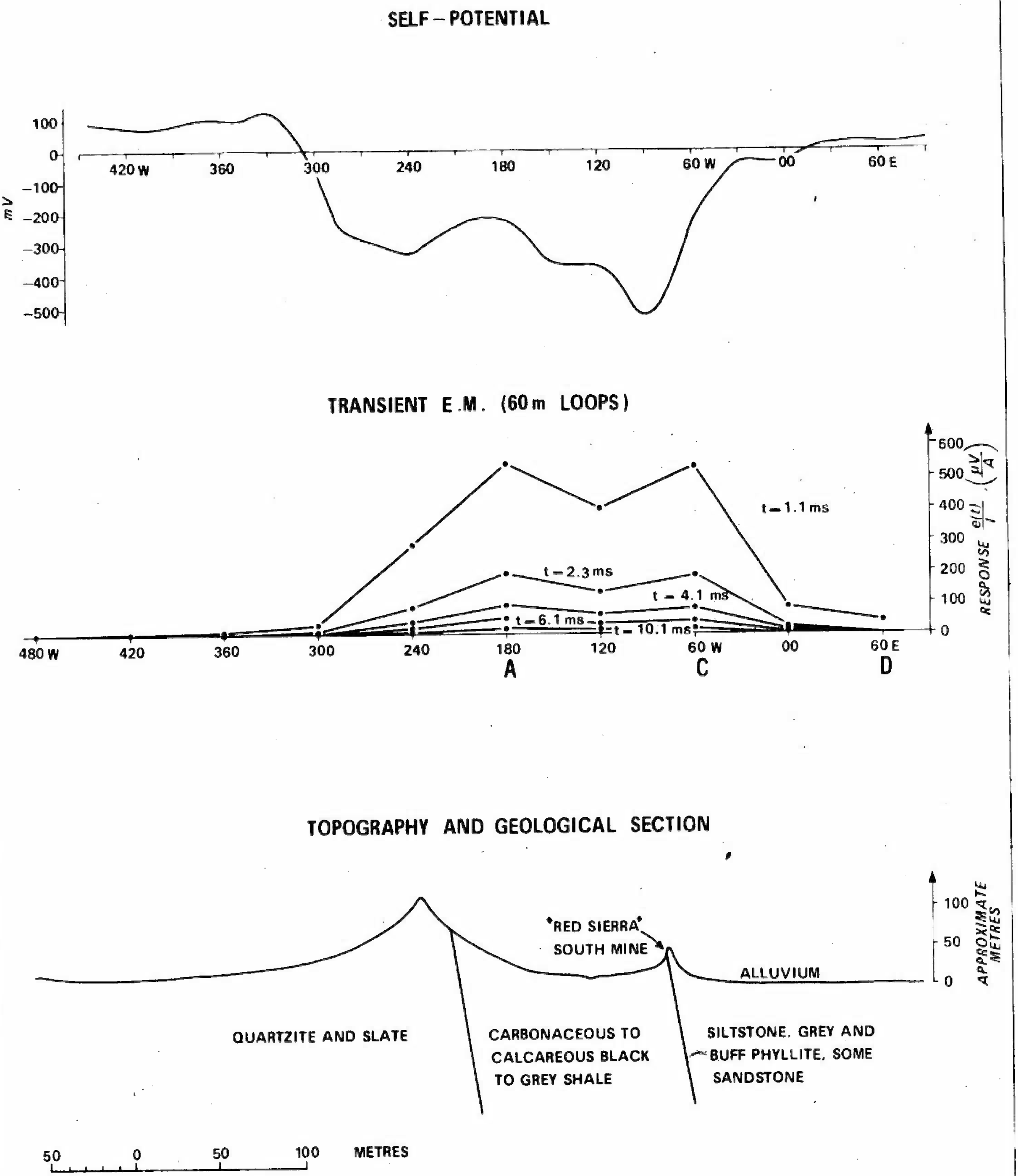
Near the Celestial mine, medium to fine-grained dolerite encloses a quartz vein which strikes east and includes gossan after chalcopyrite and pyrite. Malachite, chalcocite, and minor azurite represent the main secondary copper minerals which have been mined, overall ore grade being less than 2% at this small deposit.

PLATE 12



LOCALITY MAP, CLONCURRY AREA

PLATE 13

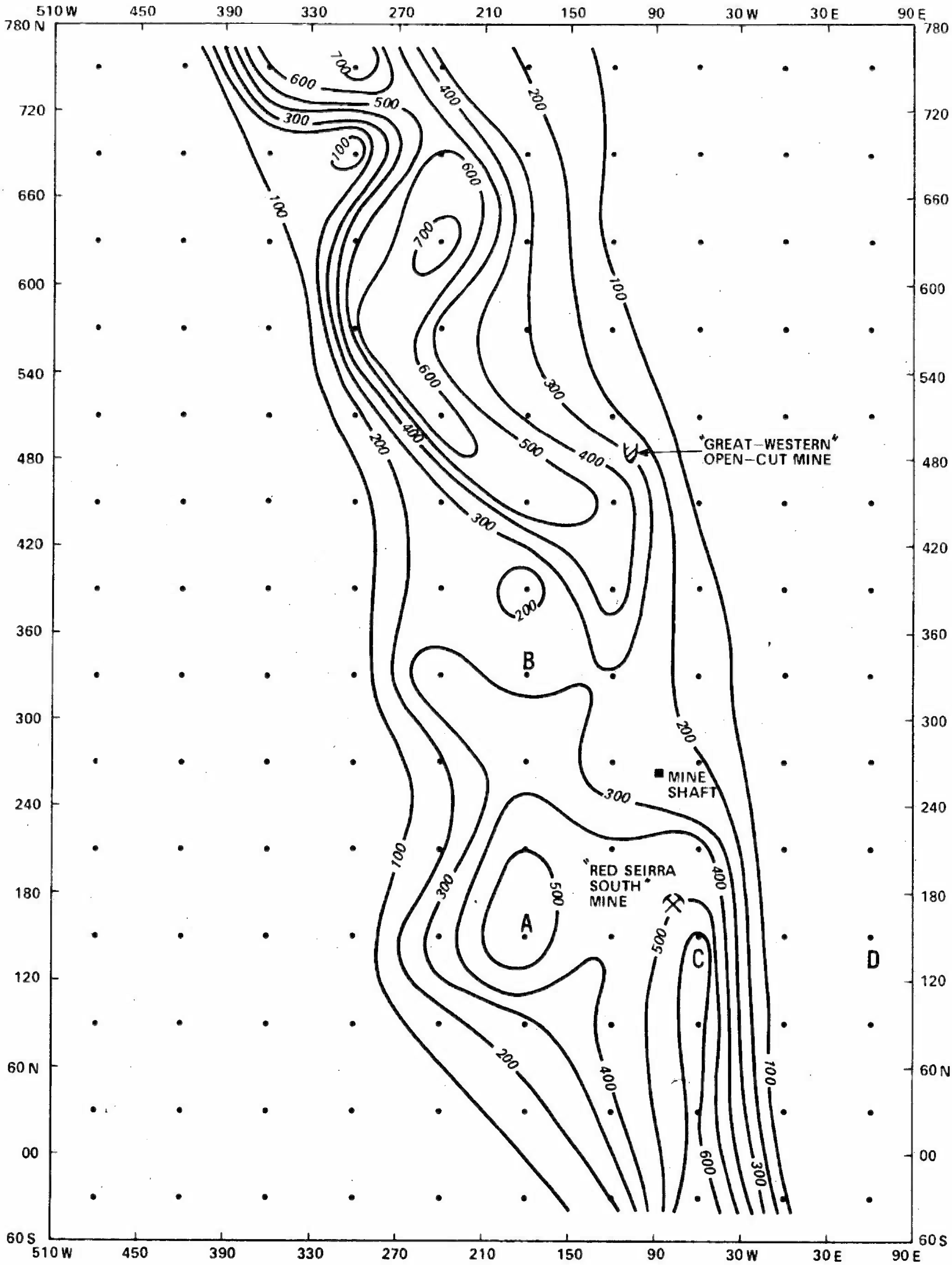


RED SIERRA SOUTH AREA,
TRAVERSE 150N (T.E.M.) 180 N (S-P)
COMPARISON OF GEOPHYSICAL METHODS
AND GEOLOGICAL SECTION

Record No. 1974/167

F 54/B7-26 A

PLATE 14



RED SIERRA SOUTH AREA

Contours of $\frac{e(t)}{I}$ in $\frac{\mu V}{A}$ for $t = 1{\cdot}1$ ms (60 m Loops)

Record No. 1974/135 and Record No. 1974/167

F 54/B7-27 A

CLONCURRY AREA, TRANSIENT DECAY CURVES

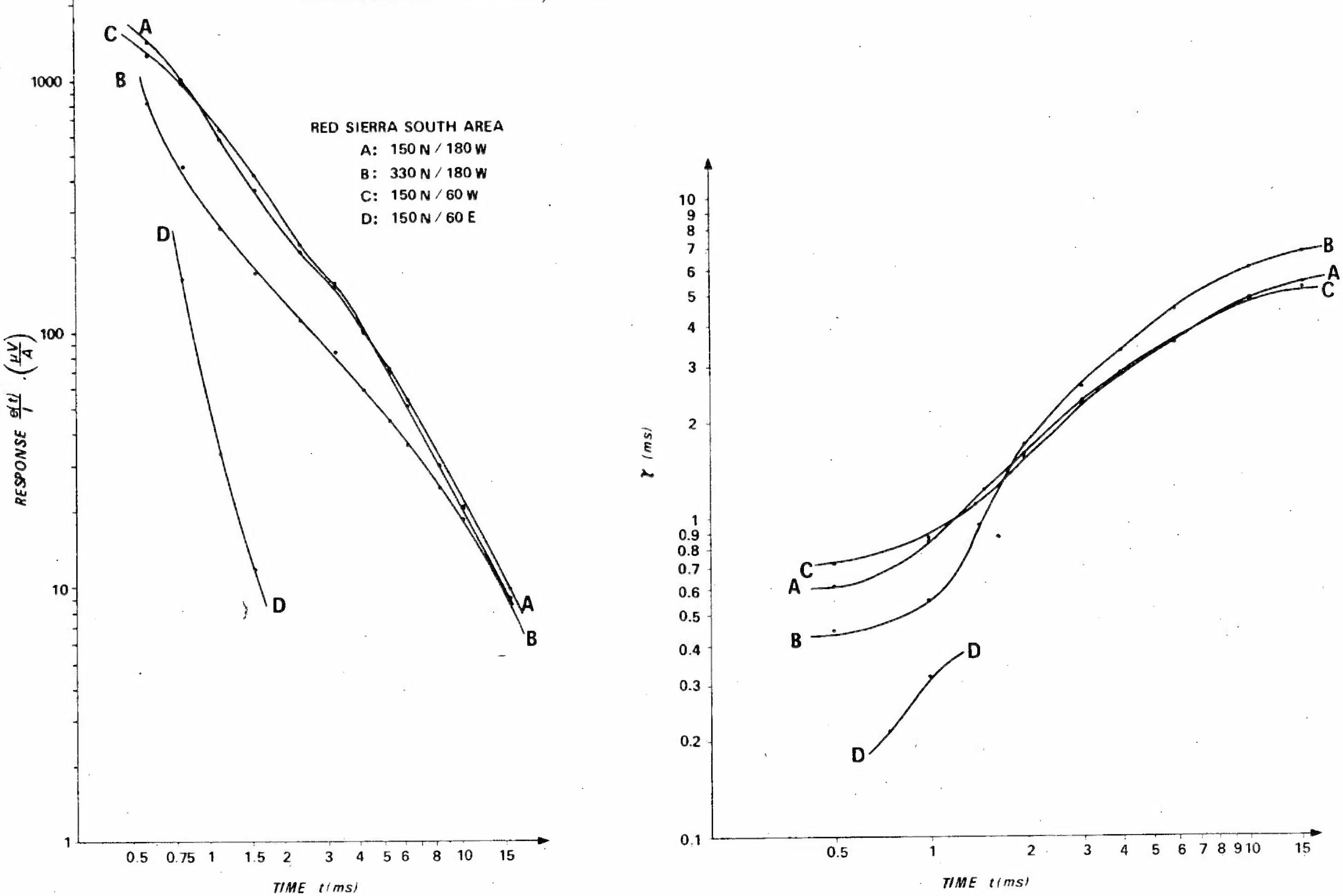
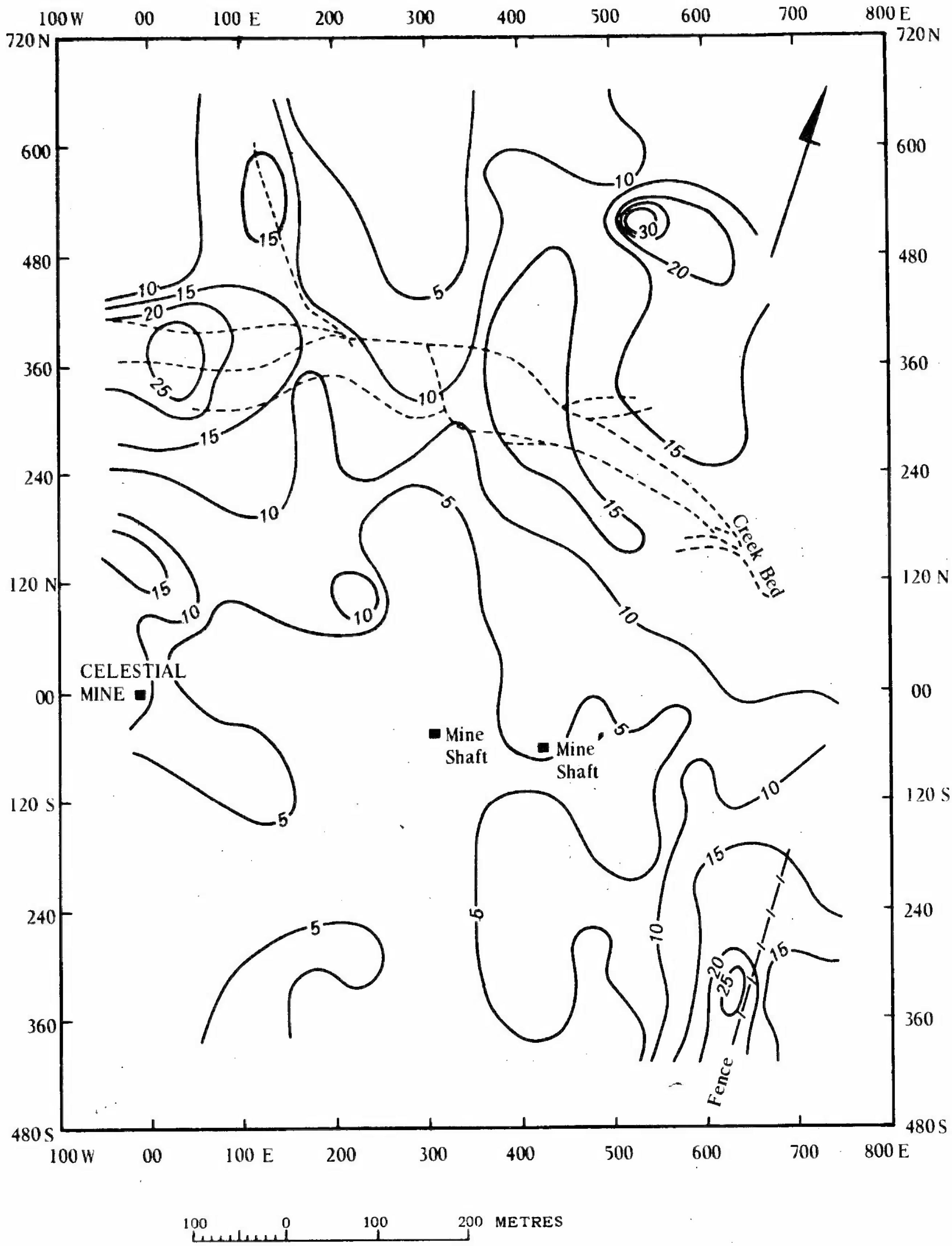
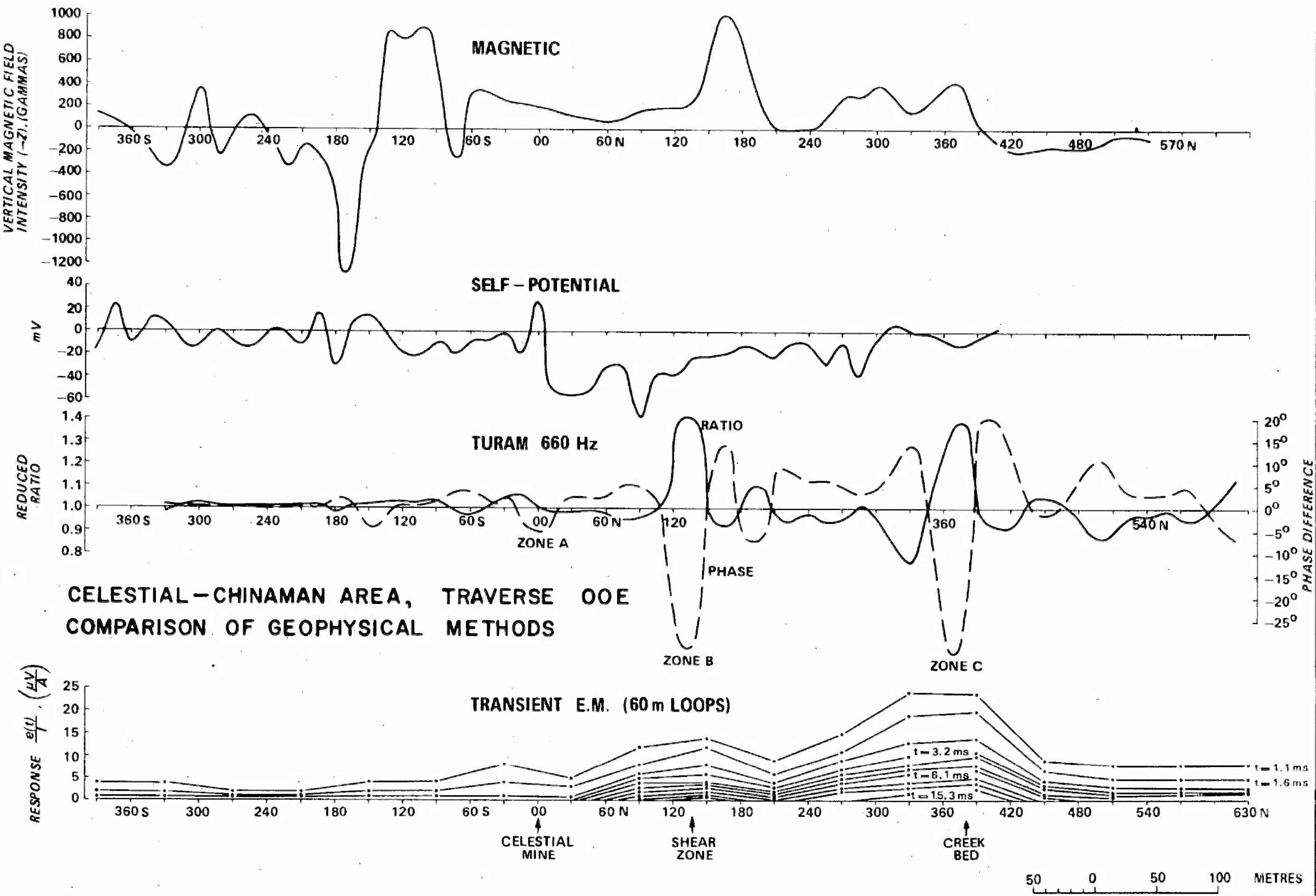


PLATE 15



CELESTIAL — CHINAMAN AREA

CONTOURS OF $\frac{e(t)}{I}$ IN $\frac{\mu V}{A}$ FOR t = 1·1ms (60m LOOPS)



F54/B7-29 A

PLATE 17

The area east of the mine was surveyed with 60-m loops as shown in Plate 16, contours e(1.1)/I being presented.

Values of e(t)/I recorded were low over the whole area, in all cases being less than 30μV for t = 1.1 ms. The main anomalous feature coincides with a creek bed at 360 N in the west of the area. This could be due to saline groundwater. The survey was conducted at the end of September, when electrical interference due to an increase in thunderstorm activity was becoming a problem. Hence in viewing the results from this area it is necessary to take into account the fact that data presented may have a large noise component.

The area was also surveyed with the magnetic, Turam, S-P, and I.P. methods (Sampath & Ogilvy, 1974). Selected data acquired over a representative traverse 00E are displayed in Plate 17. There is no definite geophysical response over the Celestial mine other than a weak Turam anomaly which persists to the east and west. The mine lies on the flank of a minor S-P anomaly, and the variations in the S-P and magnetic profiles can probably be attributed to variations in the volcanic assemblage.

The Turam results show two main anomalies which have been referred to be Sampath & Ogilvy as 'Zone C' at 360 N and 'Zone B' at 130 N. Zone C follows a creek bed and has been interpreted as being the response produced by moderately conductive saline water at shallow depths, possibly associated with a shear zone. A weak T.E.M. anomaly indicates the presence of a small yet moderately good conductor coincident with Zone C.

Zone B is also interpreted as being due to a moderately good conductor associated with a shear zone, I.P. information suggesting the presence of some sulphide mineralization. The transient E.M. anomaly is similar to that at Zone C but smaller in amplitude.

There is no T.E.M. anomaly associated with the weak Turam anomaly near the mine; hence it is unlikely that sulphides are present in any quantity, a hypothesis supported by I.P. data.

Dawn area

The Dawn area, about 2 km north of the Celestial area, also lies within the Marraba Volcanics. The area was surveyed with 60-m loops.

Values of e(t)/I were below 20μV over the whole area. These values lie within the 'noise level' and although a small anomaly was outlined near the Dawn mine, corresponding with a weak Turam and I.P. anomaly observed by Sampath & Ogilvy (loc. cit.), the results are not considered accurate enough to present in profile form.

Timberu area

In this area disseminated copper mineralization (averaging 0.5%) occurs sporadically in a belt of scapolite-bearing limestone, granofels, and calc-silicate rocks. These metasediments belong to the lower Corella Formation; they dip steeply and show minor drag folding along shears.

Readings were made using 60-m loops on three traverses surveyed by Sampath & Ogilvy (loc. cit.) over the Lakeview Dolerite dyke. No significant T.E.M. anomalies were found, all readings for time t = 1.1 ms being less than 15μV.

7. RESULTS, MARY RIVER

Regional geology

The areas surveyed at Mary River as shown in Plate 18 lie within the Ban Ban and Goodparla North 1:63 360 geological sheets.

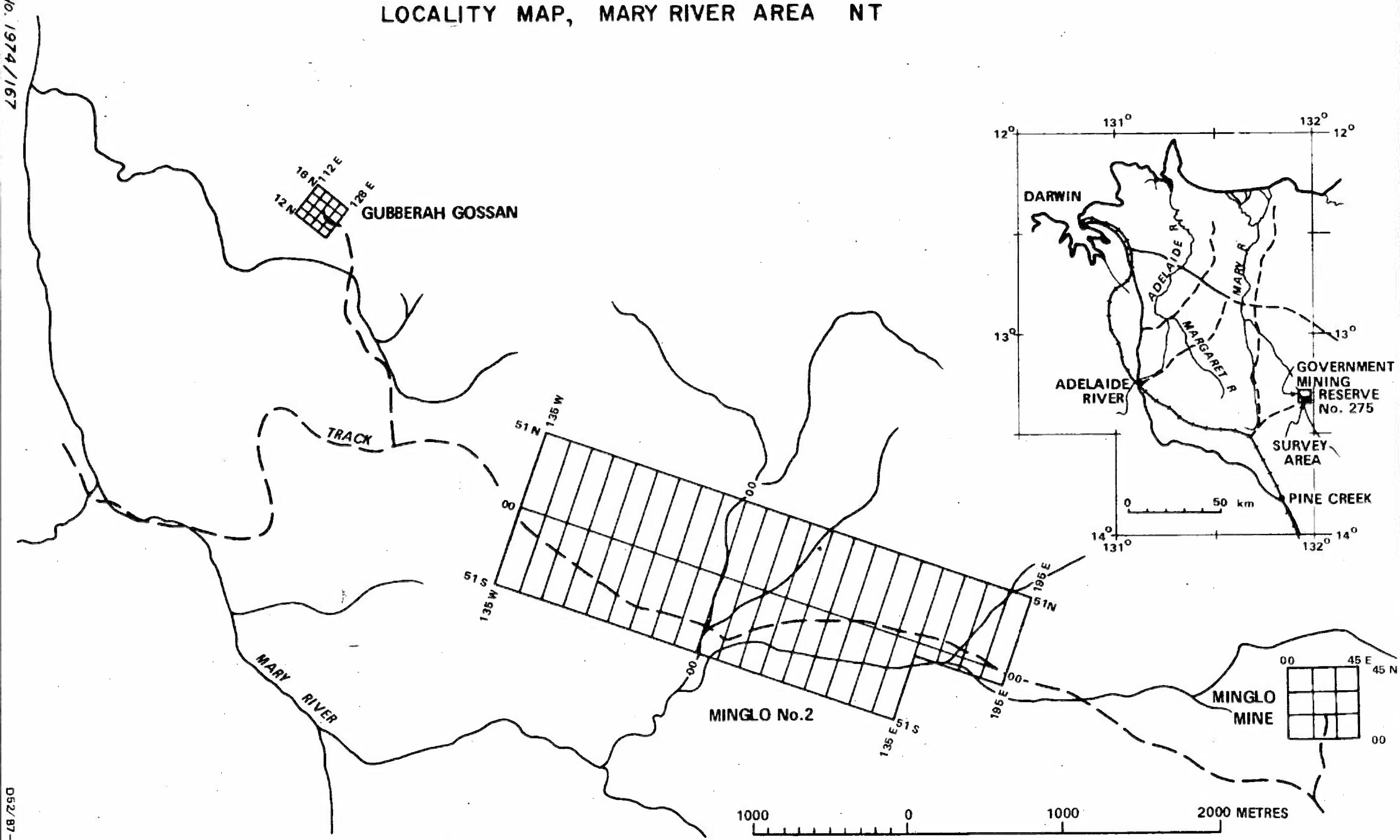
Outcrop in this locality is poor, sedimentary rocks exposed being of the Masson Formation, a unit of the Lower Proterozoic Goodparla Group. These sediments consist of interbedded quartzite, greywacke, sandstone, siltstone, and carbonaceous shale which strike northwest and dip steeply to the west. They are intruded to the south by the Cullen Granite. Alluvium and ferricrete cover much of the area, extensive black soil plains being commonly underlain by shale.

Known sulphide mineralization is restricted to zinc-lead intersected by two drill-holes at the Gubberah Gossan and recovered from minor workings at the Minglo mine.

Previous geophysical work

In 1967 Duckworth carried out a geophysical survey in the Gubberah Gossan locality to determine whether sulphide mineralization exists at depth beneath the gossan and to ascertain the significance of an anomalous geochemical zone to the south (Duckworth, 1969). Two Slingram anomalies were delineated. One, approximately 700 m west of the gossan, was interpreted as being caused by a steeply dipping conductive graphitic shale bed; the other, which trended north, 500 metres south of the gossan, was considered to represent an extension of the gossan. A self-potential anomaly which appeared to extend to the gossan coincided approximately with the latter. It was not possible to carry

LOCALITY MAP, MARY RIVER AREA NT



Record No. 1974/167

D52/B7-625A

PLATE 18

the Slingram traverses right up to the gossan because of the rough terrain, but Duckworth concluded that sulphides do underlie the gossan and possibly extend to the south.

In June 1972, a detailed low-level aeromagnetic survey was flown over the area immediately east of Mary River. Anomalous zones were subsequently investigated in a ground geophysical survey (Michail, in prep.) using Turam, Slingram, gravity, magnetic, and S-P methods, the results of which form a basis for comparing T.E.M. data.

Gubberah Gossan

Auger holes drilled in 1970 indicated that in this locality interbedded sandstone, carbonaceous shale, and siltstone occur in approximately equal proportions (Daly, 1971). Outcrop, however, is mainly restricted to sandstone exposed as ridges. Faulting and shearing occur along two main directions which trend approximately northwest and northeast. The Gubberah Gossan is associated with one such northeast-trending fault and crops out over a 280-m strike length.

Holes drilled by the N.T. Mines Branch to determine the significance of the gossan intersected zones of sphalerite and galena, with minor pyrite. Carbonaceous shale was abundant in all holes, the locations of which are shown in Plate 19. Laboratory measurements on core samples gave resistivity values of about 200 ohm-m for carbonaceous shale above the watertable (oxidized zone) and between 10 and 0.1 ohm-m for fresh rock. Massive sphalerite with minor galena and pyrite mineralization intersected in DDH.3 between 85 m and 110 m yielded a resistivity of about 400 ohm-m in contrast to a pyrite-sphalerite-quartz assemblage of about 5 ohm-m.

Detailed Turam, S-P, magnetic, and gravity surveys were carried out over the gossan by Michail (1974). A number of Turam and S-P anomalies were recorded which paralleled the geological strike and were attributed to carbonaceous rocks. The positions of two of these anomalies, which have large ratio and moderate phase difference components indicative of good conductors, are shown in Plate 19. Quantitative analysis of the anomaly forms indicates that the conductors dip to the east and have their upper surfaces within 30 m of the surface.

Neither gravity nor magnetic surveys succeeded in recording outstanding anomalies associated with the gossan.

The area in the immediate vicinity of the gossan was surveyed with the T.E.M. equipment using 60-m loops. Contours of T.E.M. data for different times are presented in Plate 19, the main feature being a northwest-trending anomaly corresponding in position to the S-P and Turam anomaly axes reported by Michail. Time characteristics of a loop centred at point 'E' are shown in Plate 20. Although not shown by the time decay curve, the decay persists to 10 ms and the time constant τ_0 at late time is about 2 ms. The response is interpreted as due to unweathered carbonaceous shale.

The discontinuity in the anomaly in the vicinity of the gossan is of particular significance. Rock properties referred to previously give clear evidence of the conductive nature of the carbonaceous shales in contrast to the resistive nature of the quartz-sphalerite mineralization. Accordingly the discontinuity could be due to fissure filling by quartz and/or sphalerite along the fault plane.

The Turam survey did not show a discontinuity in a conductor axis near the gossan. So it must be concluded that the T.E.M. method offers greater anomaly resolution than the Turam method.

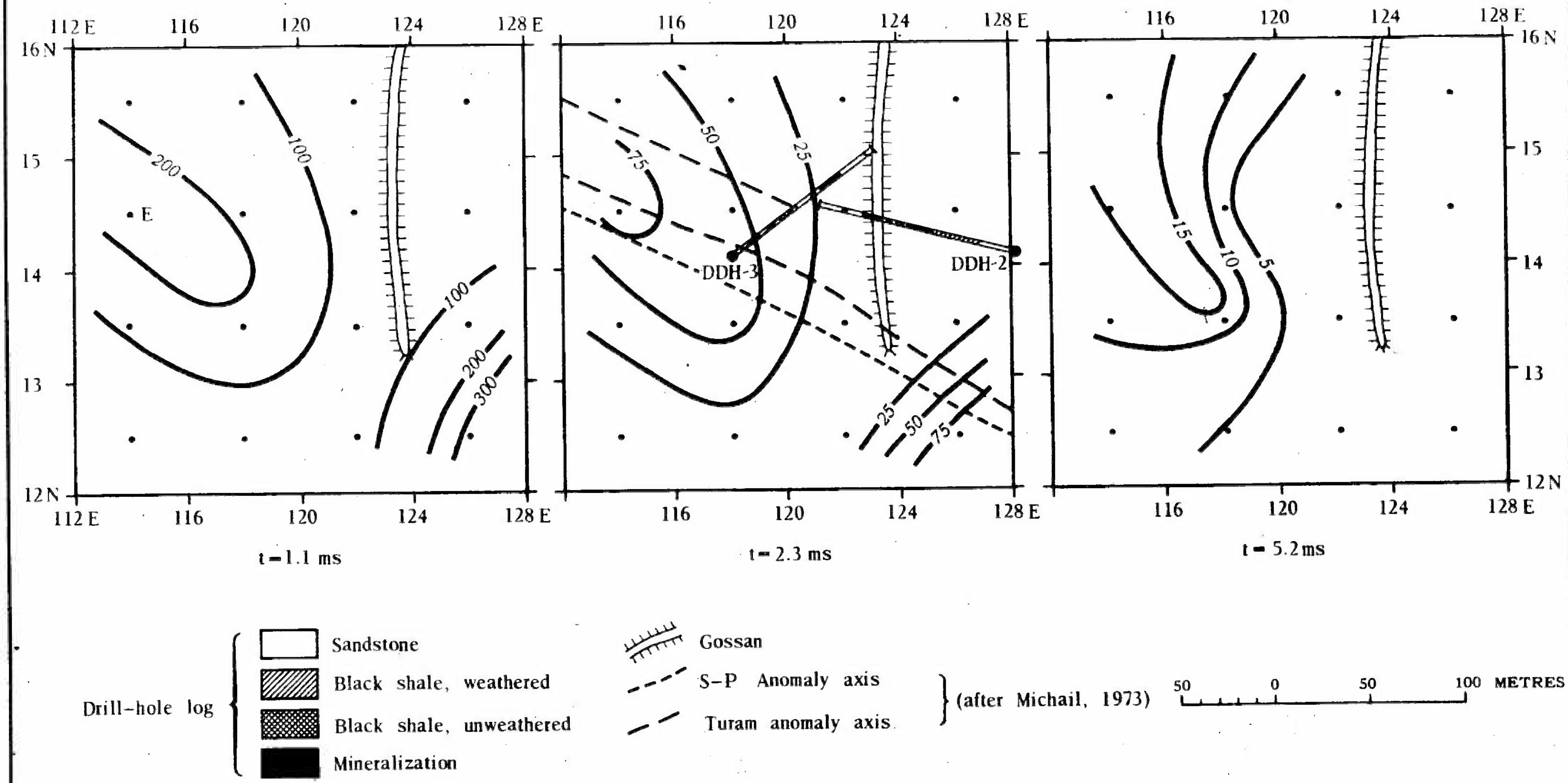
Minglo 2

Much of this area is flat, covered by up to 2 metres of alluvium and 7 metres of ferricrete. Limited outcrop, e.g. in the southern corner of the area, is predominantly sandstone. Cullen Granite crops out extensively ½ kilometre to the south of the area, thermal metamorphism being associated with the granite-sediment contact. Faulting along the contact postdates metamorphism.

The whole of the Minglo 2 area was surveyed with the T.E.M. equipment using 150 m loops. This area, of 2½ square km, was surveyed in 3½ days, which shows that the method can be used for rapid reconnaissance of large areas. Contours of T.E.M. data for t = 1.1 and 15.3 ms are presented in Plate 21. At early sample times, high values of e(t)/I occur over the entire area, which indicates that near-surface material is conductive. Variations of e(1.1)/I across the area indicate values of lateral conductivity, S, which range from 2.6 to 11 siemens. Such changes in e(1.1)/I values could be due to changes in the thickness and/or conductivity of the surficial layers.

Examination of the contour map for t = 15.3 ms reveals three well-defined anomalies, which are caused by rocks of very high conductivity, as evidenced by the decay curve for locality A shown in Plate 20. Decay curves for localities C and D are also shown, in Plate 20, the latter being interpreted as the response from a surficial deposit by virtue of the observed response

Record No. 1974/167

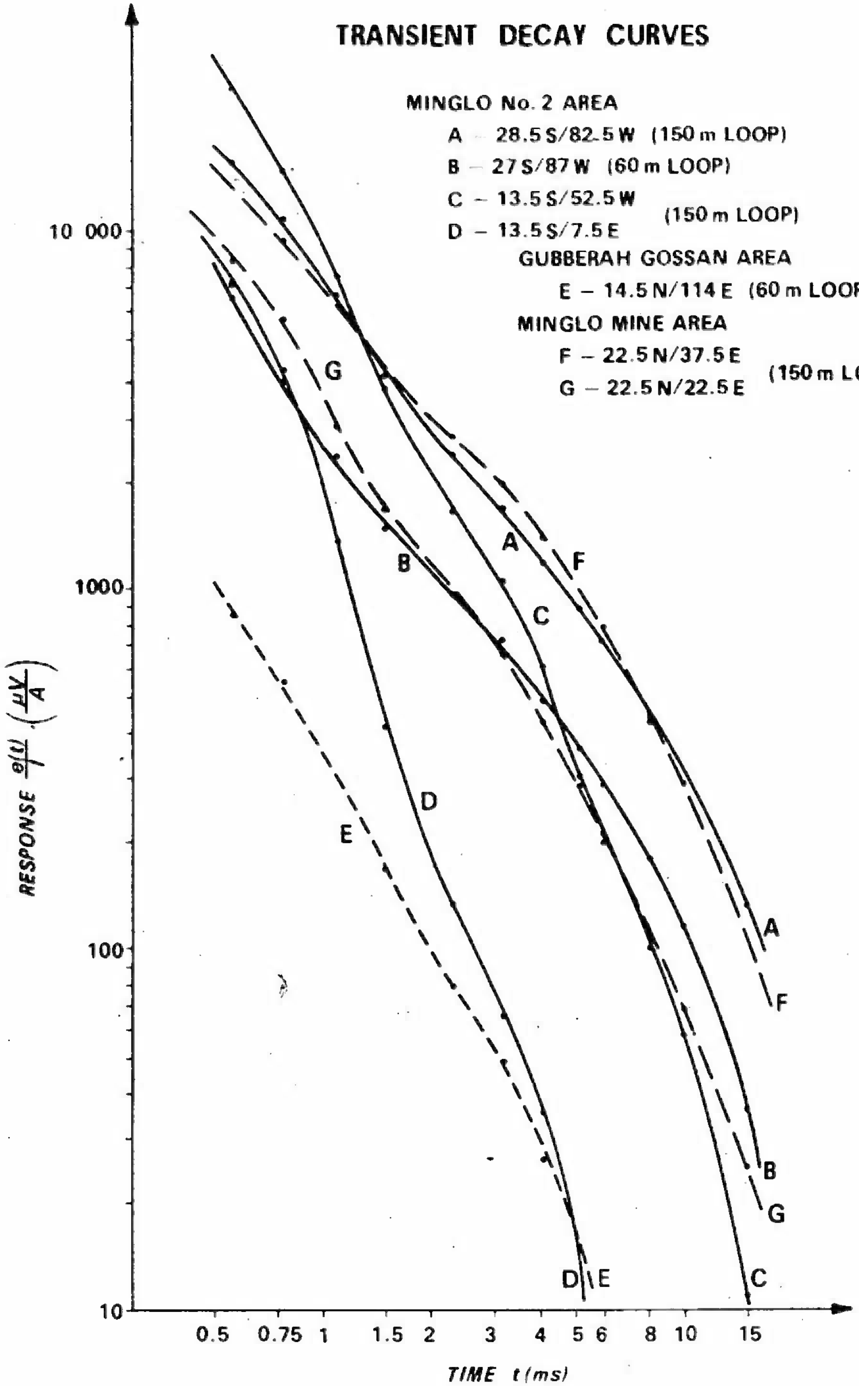


GUBBERAH GOSSAN AREA, CONTOUR OF $\frac{e(t)}{I}$ IN $\frac{\mu V}{A}$ (60m LOOPS)

PLATE 19

D62/87-831A

MARY RIVER, TRANSIENT DECAY CURVES



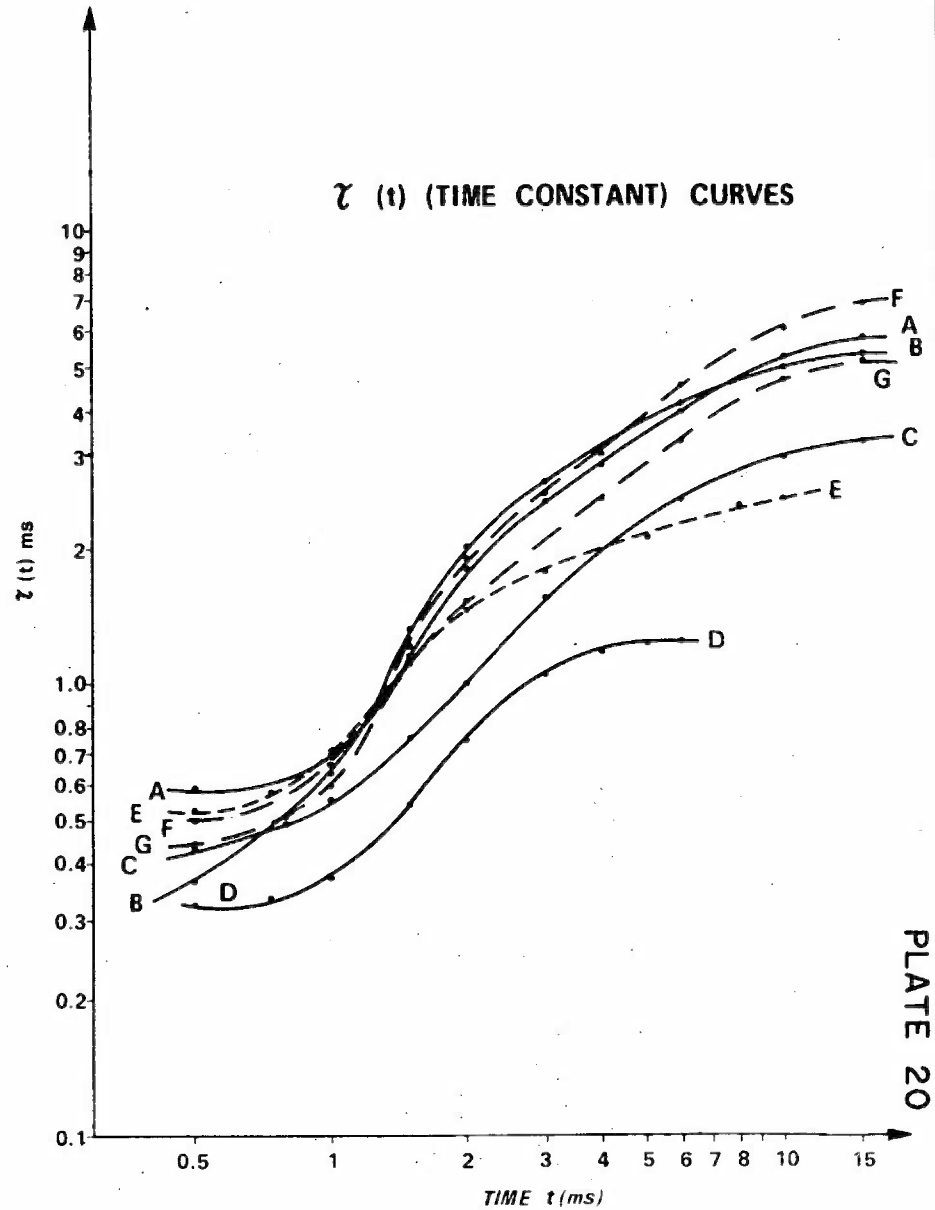
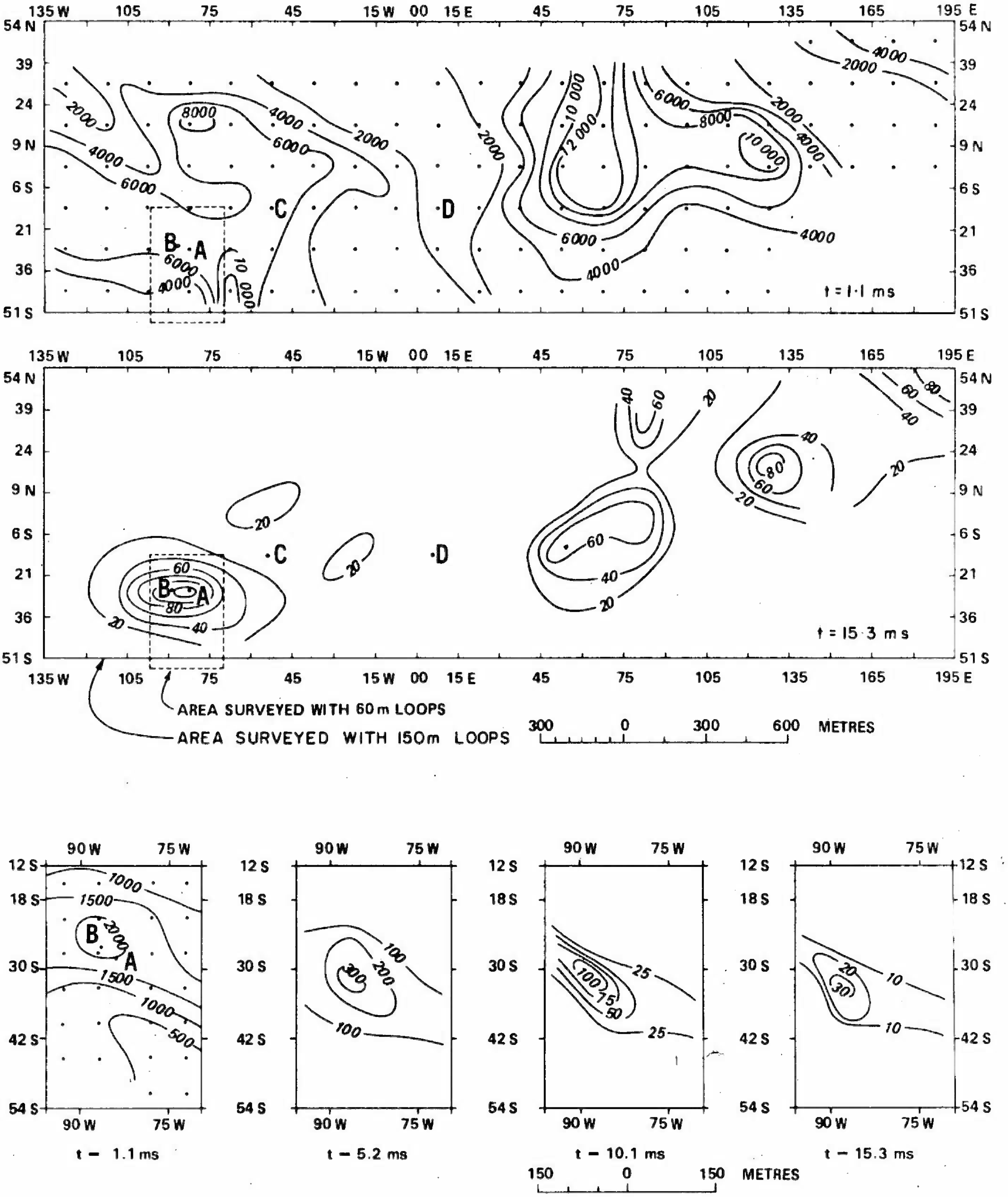


PLATE 20

D52/B7-626 A



MINGLO 2 AREA CONTOURS OF $\frac{e(t)}{I}$ IN $\frac{\mu V}{A}$

decaying to zero by 6 ms. Curve C has a response midway between A and D.

The western anomaly was surveyed in more detail using 60 m loops, as also shown in Plate 21. At 1.1 ms the anomaly is still fairly broad whereas at later times it narrows to become a thin elongated feature which strikes northwest, indicative of a fairly narrow and highly conductive source. Referring again to the transient decay curves shown in Plate 20, it is interesting to note the similarity in τ (t) curves obtained at locality B using a 60-m loop to that for locality A involving a 150-m loop. τ_o in both cases is equal to 5.5 ms. Initial comparison of field data and results from model studies indicates that the top of the body is no deeper than 20 to 30 m. Although adequate agreement can be obtained between the shapes of respective decay curves and the 60-m loop profile model and field results, such is not the case for 150-m loop profile results with specific reference to anomaly amplitudes.

In order to account satisfactorily for an amplitude difference between model and field results in this instance, it is necessary to invoke a model which increases in cross-sectional size with depth.

Results from magnetic, Slingram, Turam, VLF and S-P surveys in this area have been described by Michail (1974). A comparison of typical results from these methods with T.E.M. data involving the area of more detailed survey is presented in Plate 22. The association of a broad magnetic high with the T.E.M. anomaly at 28S suggests rock alteration attributable to the neighbouring Cullen Granite.

The Slingram data reveal numerous complex anomalies which tend to be more pronounced in the real component than in the imaginary component, indicating their sources to be moderate conductors. These conductors are considered to be contained within the zone of oxidation as the frequency used was fairly high (1760 Hz). The T.E.M. anomaly is in no way distinctly reflected by the Slingram data, the latter probably representing only conductivity changes in the surficial layers.

The length of the Turam profile along 90 W was limited by low signal strengths at distances greater than 200 m from the primary loop. Results from Turam work in general were similar to those of Slingram and did not contribute any additional information of significance.

Neither VLF or S-P data yielded distinctive anomalies or results which could be sensibly correlated between adjacent traverses or with other geophysical data.

Michail infered from the results described above that carbonaceous shale and alluvium derived from it represent the sources of the extensive EM anomalies recorded at Minglo 2 by Slingram and Turam surveys. Greater resolution of conductor axes was possible from these surveys than from the T.E.M. survey as no loop-overlap was used with the latter. However, the value of this result must be questioned as it is known that the Slingram data in particular reflects poor to medium near-surface conductors whereas T.E.M. data recorded at late sample times highlight the more useful anomalies representative of unweathered conductive rock units located beneath surficial conducting material.

Minglo mine

The Minglo mine is associated with a sharply defined shear zone. Host rocks to mineralization show evidence of contact metamorphism attributed to the nearby Cullen Granite (Walpole et al., 1968). The ore consists of galena surrounded by bands of anglesite.

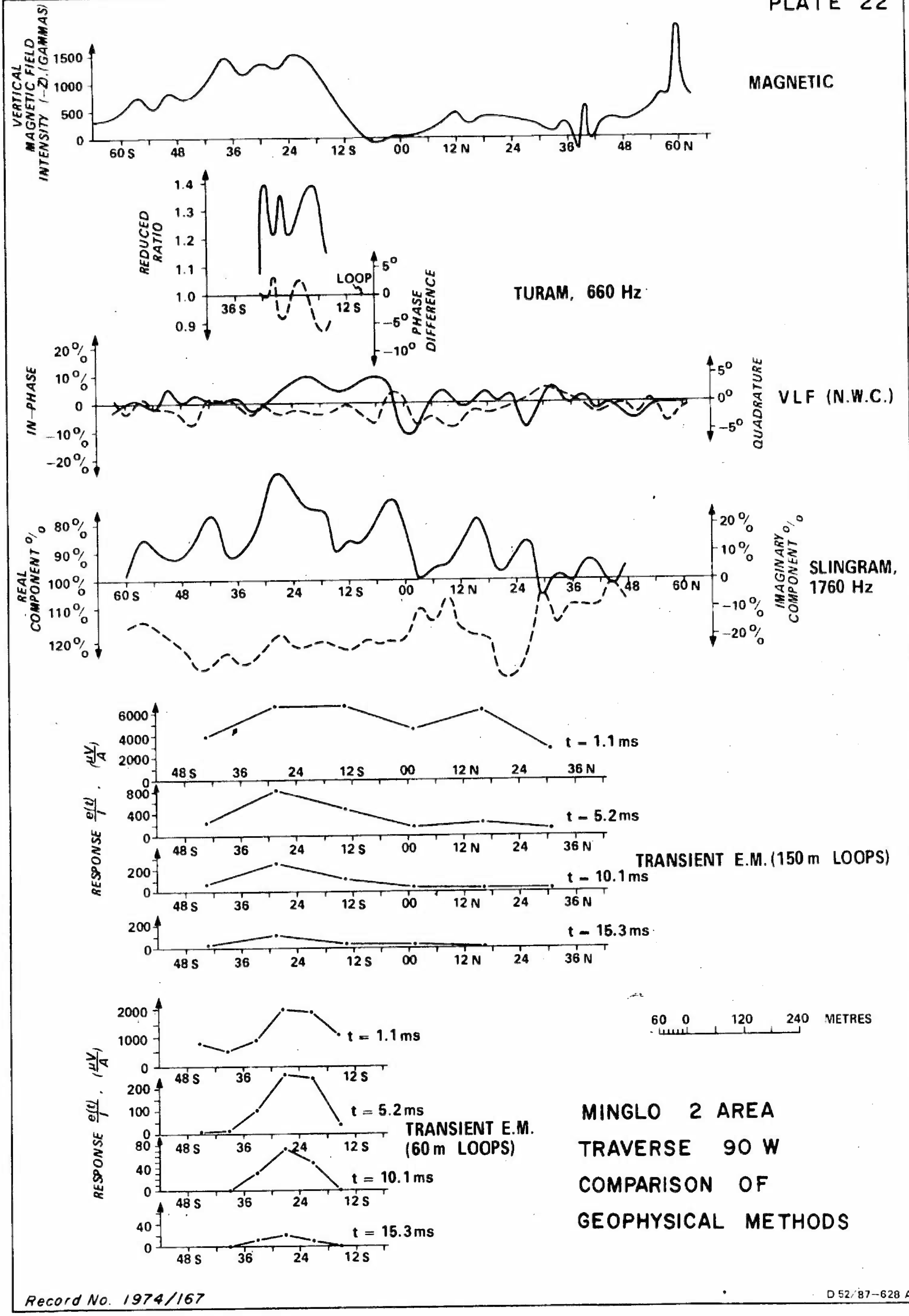
The area was surveyed using 150-m loops, and the results are presented in Plate 23. No distinctive anomaly is associated with the mine, e(t)/I values generally increasing towards the southeast. Transient decay curves for locations F and G shown in Plate 20 are very similar to those obtained in the Minglo 2 area over carbonaceous rocks (curves A and B). Curve G was obtained with a loop directly over the mine whereas curve F was obtained to the east, where the T.E.M. values are greatest. The similarity of all these curves on the $\gamma(t)$ graph implies that the sources of the anomalies are similar in both areas, and thus at the Minglo mine no anomalous response can be uniquely attributed to sulphide mineralization.

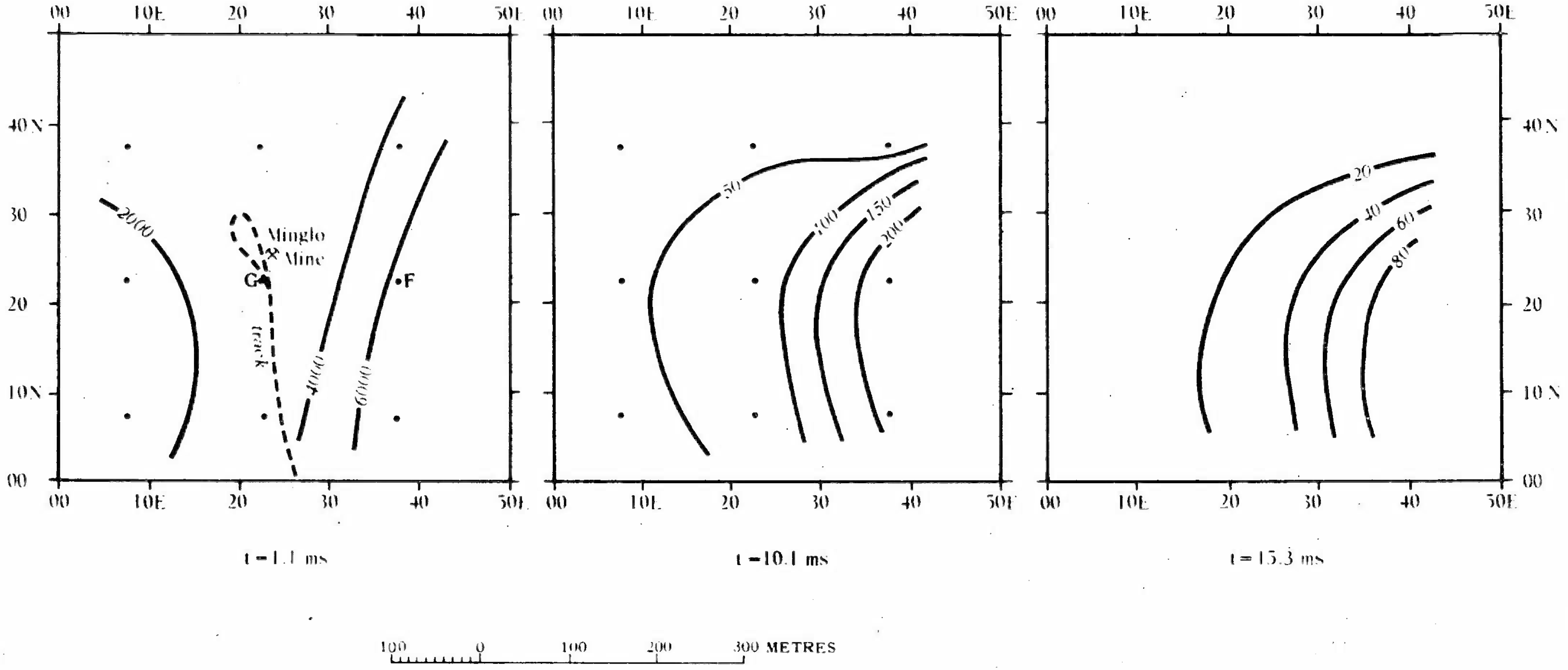
8. CONCLUSIONS AND RECOMMENDATIONS

The T.E.M. method offers considerable advantages over conventional E.M. systems in that the measurement of the response at different sample times is equivalent to multi-frequency measurements for a harmonic source. Large loops should be used for a reconnaissance survey so that large areas can be covered quickly; anomalous area defined should be resurveyed using smaller loops, with loop overlap to delineate anomalies accurately to assist quantitative interpretation.

The low power output of the MPPO-1 equipment commonly results in poor signal-to-noise characteristics which can severely limit survey application. Areas selected for field trials included both good and poor conductors. The most important conclusions obtained from the work in these areas follows.

PLATE 22


VERTICAL MAGNETIC FIELD INTENSITY (-Z) (GAMMAS)
MAGNETIC
REDUCED RATIO
PHASE DIFFERENCE
LOOP
TURAM, 660 Hz
IN-PHASE
QUADRATURE
VLF (N.W.C.)
REAL COMPONENT %
IMAGINARY COMPONENT %
SLINGRAM, 1760 Hz
RESPONSE e(t)/I, (µV/A)
t = 1.1 ms
t = 5.2 ms
t = 10.1 ms
t = 15.3 ms
TRANSIENT E.M. (150 m LOOPS)
TRANSIENT E.M. (60 m LOOPS)
60 0 120 240 METRES
MINGLO 2 AREA
TRAVERSE 90 W
COMPARISON OF
GEOPHYSICAL METHODS



MINGLO MINE AREA, CONTOURS OF $\frac{e(t)}{I}$ IN $\frac{\mu v}{A}$ (150m LOOPS)

PLATE 23

D52/B7-630A

Rum Jungle

Large responses were obtained over black shale in both the Mount Minza and Woodcutters areas. Correspondence of anomalies with those obtained by other geophysical methods was excellent. Further work should be done in areas where Slingram depth probes have been carried out and/or resistivity information is available, to enable estimates of depth penetration to be made for different loop sizes.

Tennant Creek

The results at Tennant Creek suggest responses from near-surface conductive layers which probably constitute the oxidized zone or layers of saline water. Transient decays are characterized by a small time constant and were in some cases exponential. No anomalies were obtained over ironstone bodies, indicating that such bodies do not have appreciable conductivity contrast with the host-rock. Resistivity depth probes are warranted in areas C6 and C11 to determine the disposition and resistivity of conducting layers. No further T.E.M. work is recommended.

Cloncurry

In the Red Sierra South area a large response was obtained over black shales. Estimates of resistivity calculated from the T.E.M. data agree closely with laboratory measurements of rock samples collected. The value of the T.E.M. method was demonstrated in this area of high ground conductivities and rugged topography by the fact that useful data were obtained where other geophysical methods such as Turam, Slingram, and I.P. proved to be ineffective.

Anomalies recorded at other test localities were small, T.E.M. data in general showing a limited correlation with Turam and I.P. results. Electrical interference was a common problem in these areas owing to the low signal levels.

Mary River

No response directly attributable to mineralization was obtained in this area. At Gubberah Gossan the T.E.M. work was successful in revealing the presence of a discontinuity in a conductivity high coincident with the gossan. The discontinuity is interpreted as being caused by resistive quartz and sulphide mineralization infilling a fissure within carbonaceous rocks. The receiver/transmitter loop configuration of the T.E.M. method provided greater resolution of this feature than was obtainable from the Turam method. It was not practicable to carry out a Slingram survey at this locality owing to ruggedness of the topography.

In the Minglo 2 area a number of anomalies were delineated which were attributed to surficial conducting material located within the zone of oxidation and highly conductive rock units which underlie this zone. Some similarity to Slingram survey results was observed in the former case. Further detailed work is recommended near 30S/90 W to define a drill target to establish the source of the anomaly detected at this locality.

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