DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1976/99

TRANSIENT ELECTROMAGNETIC SURVEY, ELURA PROSPECT, COBAR, NEW SOUTH WALES, 1974

by

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ILLUSTRATIONS

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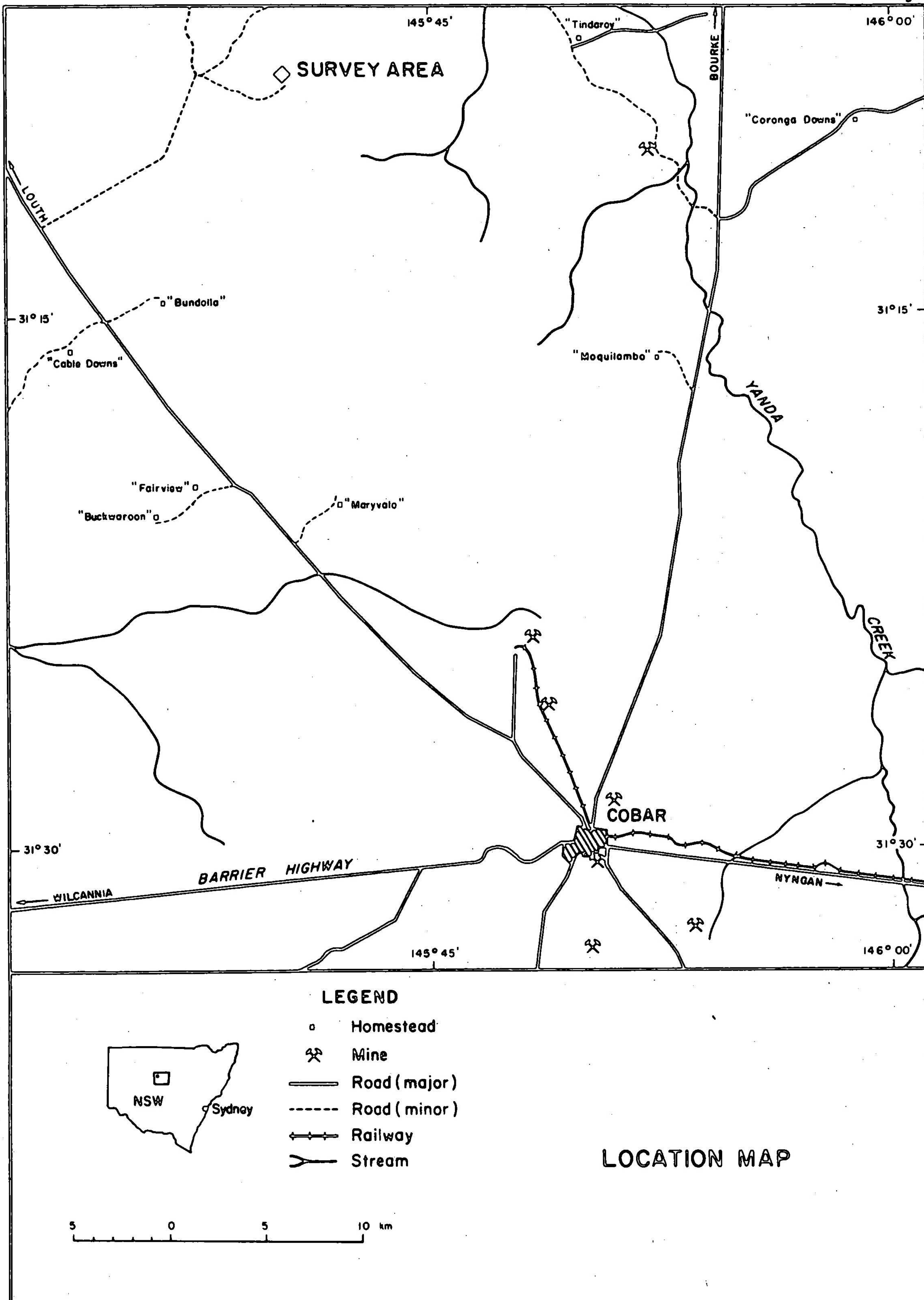
SUMMARY

During December 1974 the Bureau of Mineral Resources made a transient electromagnetic survey at Elura prospect, near Cobar, New South Wales, to determine the response to TEM of a massive sulphide body beneath a zone of conductive overburden.

Using 200-m and 100-m loops, anomalies were recorded near the mineralization; however a low signal-to-noise ratio at late delay time prevented their quantitative interpretation. The source of these anomalies is believed to be sulphide stringers or weathered mineralization above but related to the body of massive sulphides.

The survey clearly demonstrated the ability of the TEM method to detect a body of high conductance beneath a conductive overburden.

Fig. 1



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1. INTRODUCTION

During December 1974 the Bureau of Mineral Resources (BMR) carried out a transient electromagnetic (TEM) survey of Elura prospect, near Cobar, New South Wales (Fig. 1). The survey was undertaken with the co-operation of the Electrolytic Zinc Company of Australia (EZ) and was designed to determine the response to the TEM method of a massive sulphide body beneath a zone of conductive overburden.

The survey comprised six traverses in a 1 km x 500 m gridded area containing a body of massive sulphide mineralization beneath a zone of weathering and high conductivity up to 90 m thick. The massive sulphide body has not been fully delineated, but is known to be a vertical pipe-like body 200 x 50 m in cross-section and over 400 m in vertical section. The locations of the traverses and the axis of the massive mineralization are shown in Figure 2. The survey was conducted with the Russian built MPPO-1 equipment modified by BMR to improve reliability.

Personnel engaged on the survey were I. Hone, D. Wilson, R. Cobcroft (geophysicists), and H. Reith (Technical Assistant).

2. GEOLOGY

The Elura prospect lies northwest of the main ore deposits of the Cobar region. The regional geological setting and mineralization of the area is described by Rayner (1969) and Suppel & Stevens (1973).

The survey area is flat with extensive alluvial cover and little outcrop. The Elura prospect is considered to lie within the Lower Devonian Amphitheatre Beds, which rest unconformably on the Cobar Group. Preliminary mapping based on drilling revealed a deeply oxidized zone about 90 m thick, below which the country rock consists predominantly of massive siltstone interbedded with thin bands of fine sandstone and greywacke. The formations are strongly deformed, but indicate an approximate north-northwest strike and a dip to the east of 70°-80°.

There is no surface expression of mineralization, but drilling of geochemical and geophysical anomalies intersected massive sulphide mineralization below the base of oxidation. The mineralization consists predominantly of massive pyrite with significant galena and sphalerite.

3. PREVIOUS GEOPHYSICAL INVESTIGATIONS

In August 1973, Seigel Associates Australasia Pty Ltd carried out two IP/resistivity depth-soundings and ten gradient-array IP traverses in the area. This survey, designed to assess the geo-electric environment and outline possible subsurface mineralization, indicated a zone of anomalous chargeability centred below 19980mN/20200mE.

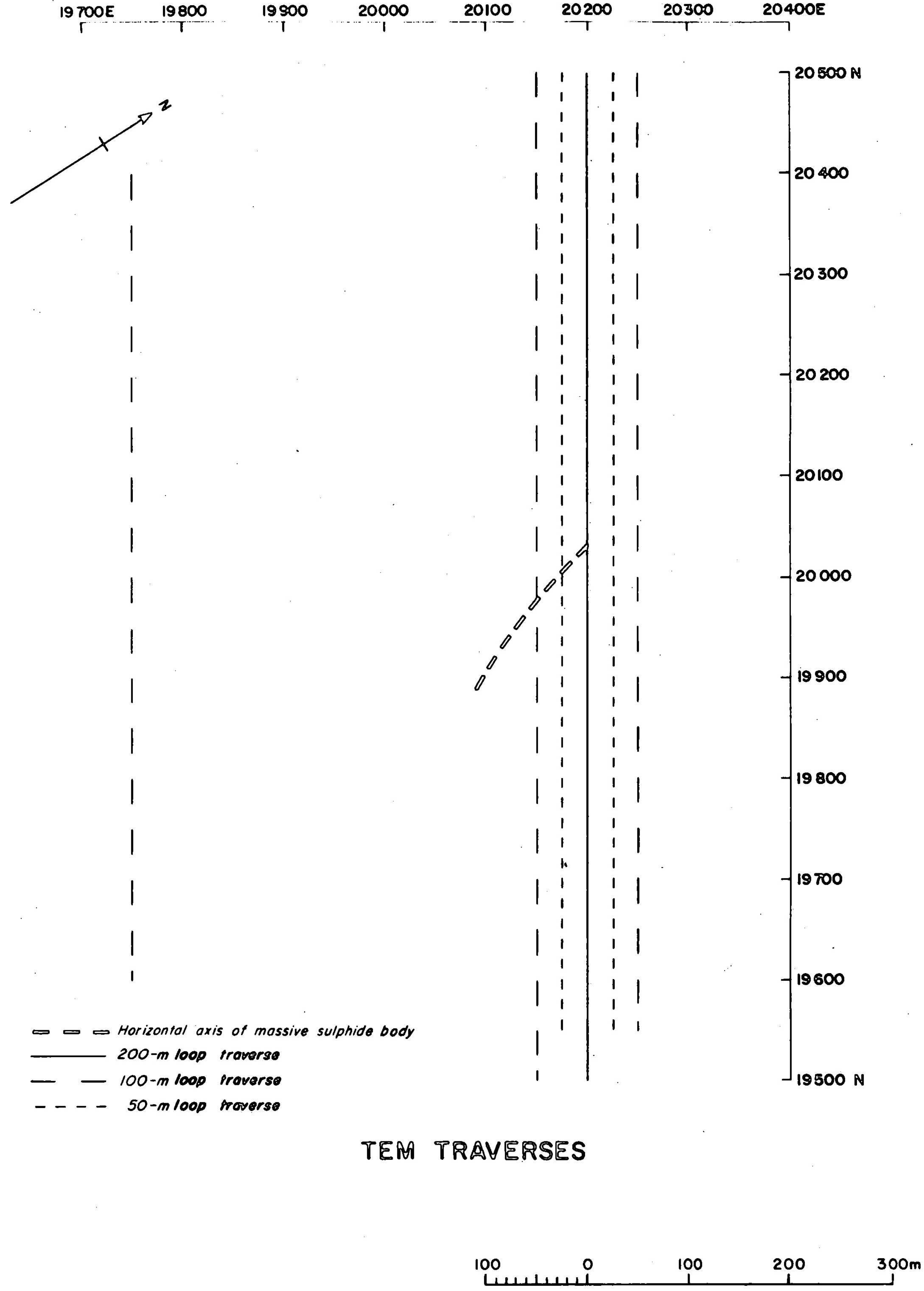
Magnetic, radiometric, gravity, electromagnetic, resistivity, and self-potential surveys were also made over the prospect by EZ. Coincident gravity and magnetic anomalies were observed and are attributed to the sulphide mineralization intersected by drilling. The other methods did not indicate the presence of the sulphide mineralization.

Early in 1974, BMR conducted surveys in the area; the principal methods used were surface and down-hole induced polarization and mise-a-la-masse. The results of this work are described by Ogilvy (1976). They show that although surface electrical methods were only partly successful in indicating the presence of the sulphides intersected by drilling, mise-a-la-masse and magnetic surveys indicate the presence of a pipe-like sulphide body below 20000mN/20150mE.

4. THE TEM METHOD

The TEM method measures the rate of decay of eddy currents induced into subsurface conductors. These eddy currents are produced by the collapse of a magnetic field created by a rectangular current pulse in a loop of wire on the ground.

The MPPO-1 equipment uses the same loop of wire for creating the magnetic field and for measuring the decay of eddy currents in the interval between the current pulses. The decaying eddy currents produce a time-dependent emf $e(t)$ in the loop which is measured by the receiver



TEM TRAVERSES

unit of the MPPO-1 at various sample times (delay times) between ½ ms and 16 ms. To improve the accuracy of the readings the measurements are averaged over several hundred cycles. The original MPPO-1 equipment had 10 sample times, but a BMR modification allows 20 sample times to be recorded. The sample times are shown in Table 1.

TABLE 1 - MPPO-1 SAMPLE TIMES

Original settings	Delay time (ms)	Additional settings	Delay time (ms)
1	1.17	1a	0.60
2	1.59	2a	0.80
3	2.39	3a	1.19
4	3.22	4a	1.61
5	4.07	5a	2.03
6	5.20	6a	2.60
7	6.17	7a	3.08
8	8.36	8a	4.18
9	10.16	9a	5.08
10	15.48	10a	7.74

The results of the MPPO-1 survey can be presented as decay curves or as profiles or contours of the measurements at different sample times. In practice results are normalized by plotting $e(t)/I$, where I is the current in the loop. In general, eddy currents in good conductors decay more slowly than those in poor conductors, and therefore a comparison of $e(t)$ at different sample times can be used as a guide to the conductance of TEM sources.

Spies (1974) has given a detailed account of the TEM method and the equipment used by BMR. Some further points relevant to the Elura survey are discussed below.

Loop size

Loop size is variable, but square loops with side lengths of from 50 to 200 m are commonly used. Increasing the loop size increases the depth of investigation but reduces resolution and discriminates against small sources. To improve the definition of anomalies, loop overlaps are commonly used, and to increase the signal-to-noise ratio the current in the loop should be as large as possible.

Noise

The MPPO-1 receiver responds to a broad spectrum of electromagnetic radiation. Noise created by lightning, power lines, and other spurious sources will be accepted and added to the signal produced by the induced eddy currents. If the signal is small, such as at late delay times, noise may cause erroneous readings. When noise is a problem its influence can be diminished by using larger currents or smaller loops.

At Elura the signal-to-noise ratio was acceptable and meaningful results were obtained at most stations. Depending on the location and loop size used, the noise levels ranged from 5 to 25 percent at early delay times, to 50 percent at late delay times.

Effect of a conductive overburden

As shown by Ogilvy (1976) the overburden at Elura constitutes a conductive surface blanket up to 100 m thick which has a conductivity greater than 0.1 Siemens per metre.

Conductive blankets, such as the one at Elura, can give rise to very large eddy currents which saturate the amplifiers of the MPPO-1 receiver at early delay times. At later delay times the large signal produced by the conductive overburden will have decayed, and valid readings can be taken. Many of the TEM stations on the Elura grid showed the effects of saturation for delay settings 1 to 4 and 1a to 4a (refer to Table 1). However, fair quality readings were possible on all other delay settings.

5. SURVEY DETAILS

As shown in Figure 2, six TEM traverses 1 km long were made over Elura prospect. Five of the traverses passed over or near the zone of subsurface mineralization, and one traverse was made away from the mineralization for control purposes.

Loop sizes were 200 m, 100 m and 50 m, and loop overlaps of 50 percent and 75 percent were used. Details of the traverses surveyed, the loop sizes, the overlaps, and the currents used are shown in Table 2.

TABLE 2 - SURVEY DETAILS

Traverse	Loop Size (m)	Current (A)	Loop overlap
19750mE	100	1	50%
20200mE	200	½	75%
20150mE	100	1	50%
20250mE	100	1	50%
20175mE	50	2	50%
20225mE	50	2	50%

6. RESULTS

Traverse 20200mE

As shown in Figure 2, this traverse employed 200-m loops and the axis of the traverse passed close to the northern end of the vertical projection of the massive mineralization. The results are shown in Figure 3 as profiles at various delay times.

Note that at early delay times a large response which is probably attributable to the conductive overburden is recorded over the length of the traverse. At later delay times the signal has decayed considerably and an anomaly centred on station 19950mN is evident. The small peak in the profile near station 20150mN is within the noise envelope of the readings and is probably not a significant feature.

Traverse 20150mE

This traverse employed 100-m loops, and passed over the vertical projection of the mineralization at 20000mN. The results are shown in Figure 4 as profiles at various delay times.

The large uniform response observed along the length of the traverse at early delay times is again attributed to the effects of conductive overburden. At later delay times the response from the overburden has decayed considerably and a fairly broad anomaly is centered on station 19950mN.

Traverse 20250mE

This traverse employed 100-m loops and passed about 50 m northeast of the vertical projection of the massive mineralization. The results are shown in Figure 5 as profiles at various delay times.

The response along this traverse is similar to the results obtained using 100-m loops along traverse 20150mE. Note that the average signal levels are similar on both traverses. However the anomaly recorded near 19950mN on traverse 20250mE is sharper and greater amplitude than that recorded on traverse 20150mE.

Traverse 20175mE

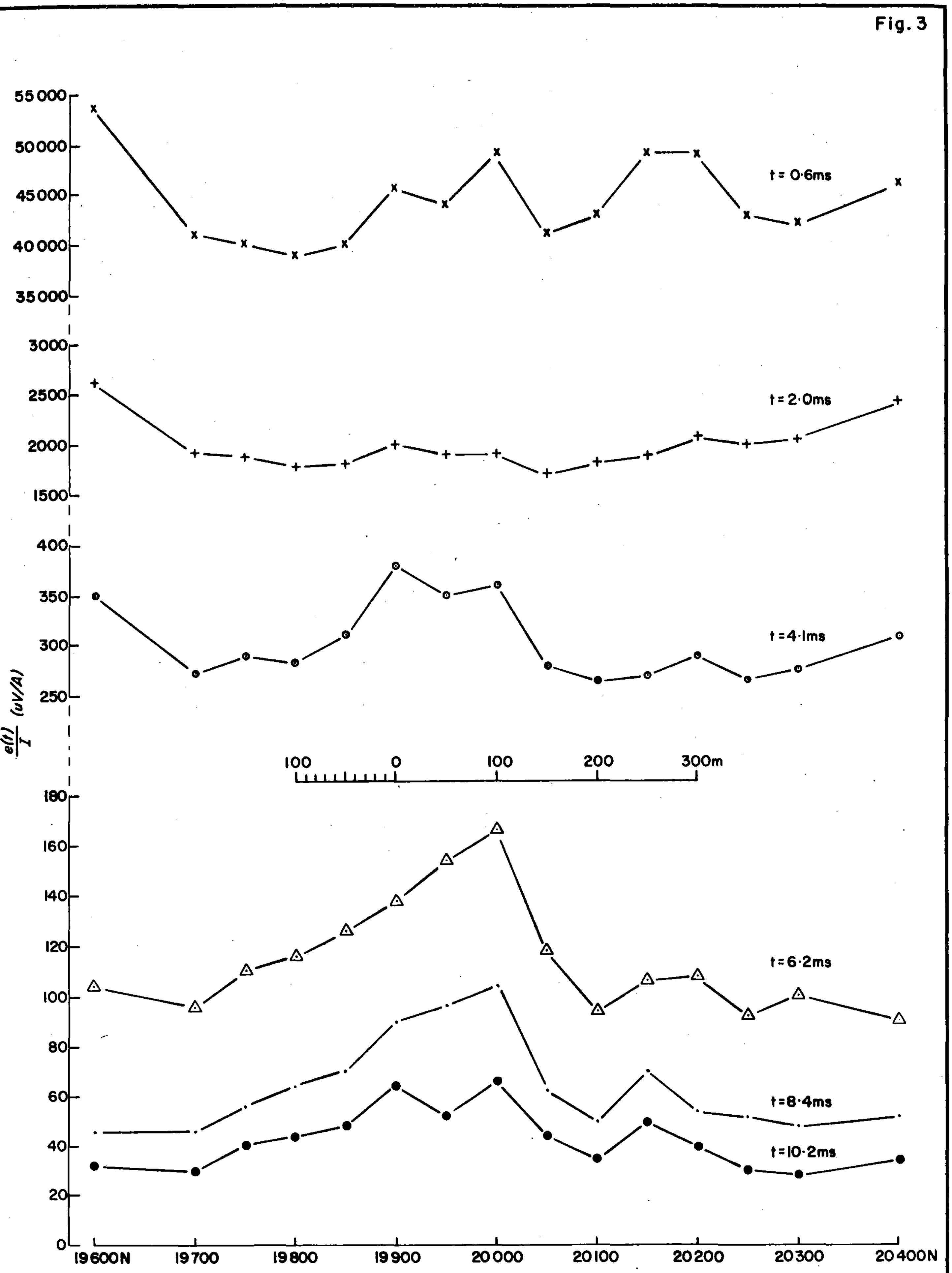
This traverse employed 50-m loops and passed over the vertical projection of the massive mineralization at 20000mN. The results are shown in Figure 6 as profiles at selected delay times. No anomalies were recorded on this traverse.

Traverse 20225mE

This traverse employed 50-m loops and passed about 25 m northeast of the mineralization. Profiles of the results at the same selected delay times as for traverse 20175mE are shown in Figure 6. The results show a generally low-amplitude response with a very sharp anomaly at 19850mN. This anomaly is attributed to metallic objects on the surface.

Traverse 19750mE

This traverse employed 100-m loops and passed 400 m to the south of the massive mineralization, and crossed an elongated geochemical anomaly. The results of the traverse for various delay times are shown in Figure 7.



TEM PROFILES, TRAVERSE 20 200E

(200-m loops)

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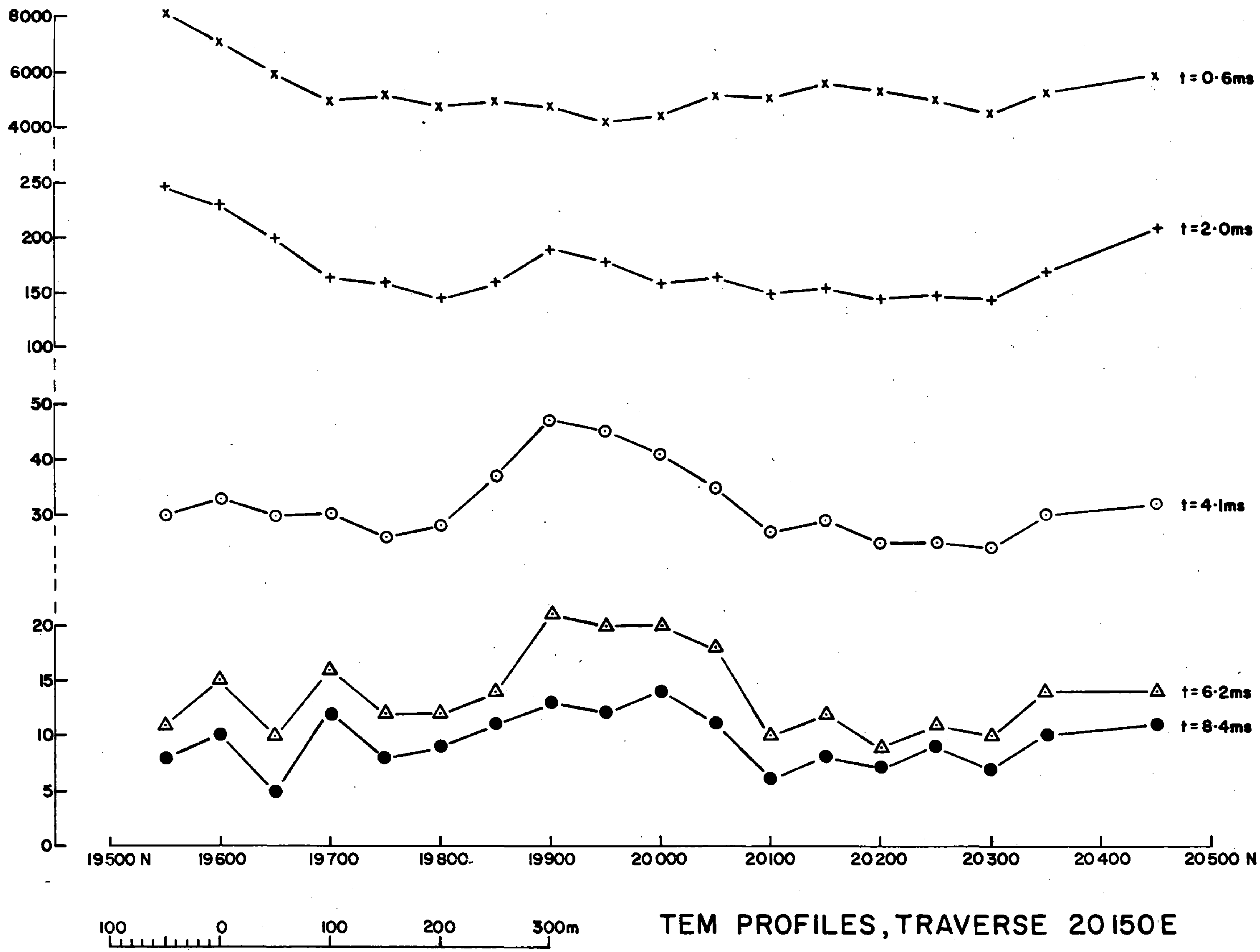

TEM PROFILES, TRAVERSE 20150E

(100-m loops)

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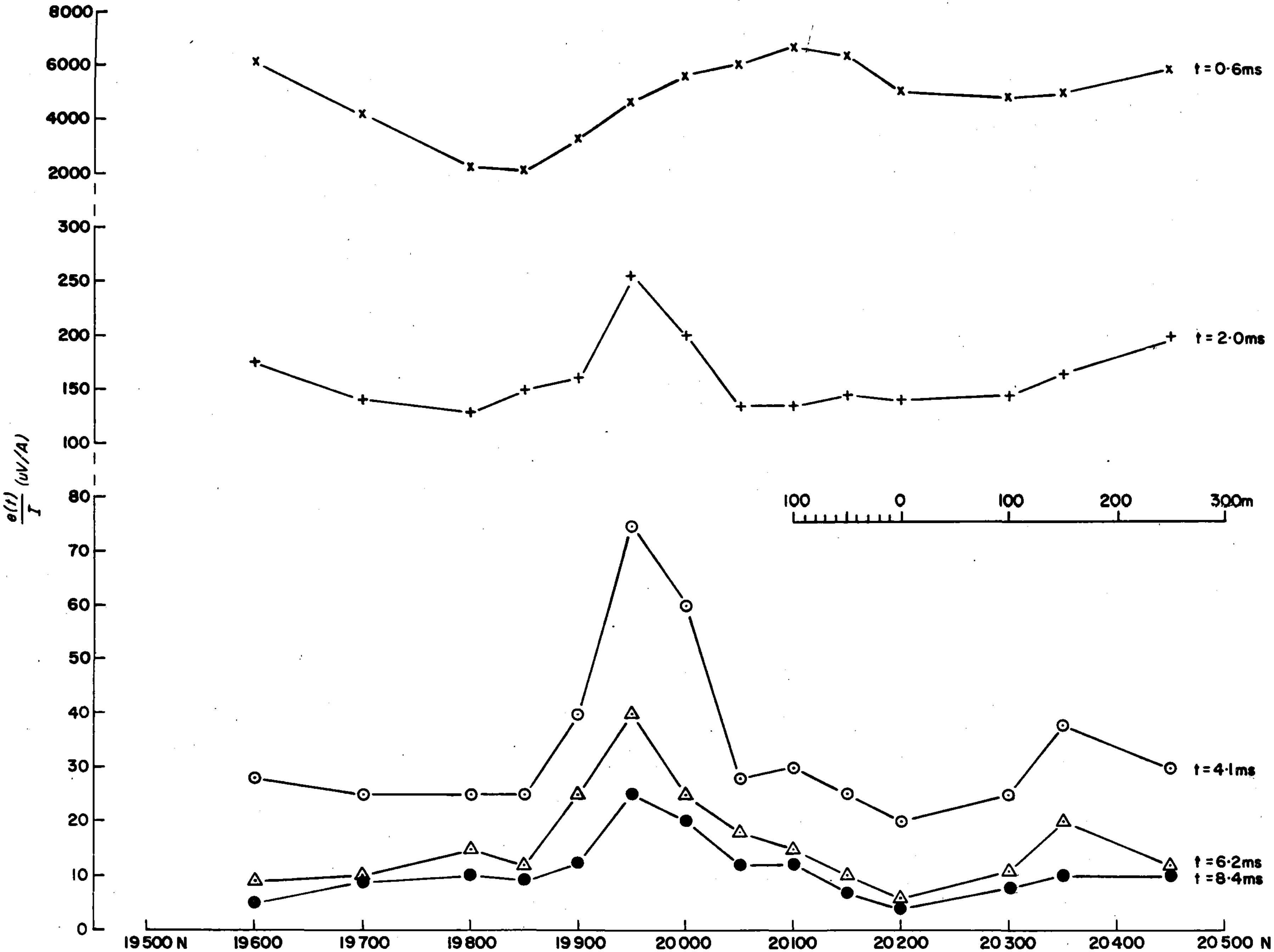
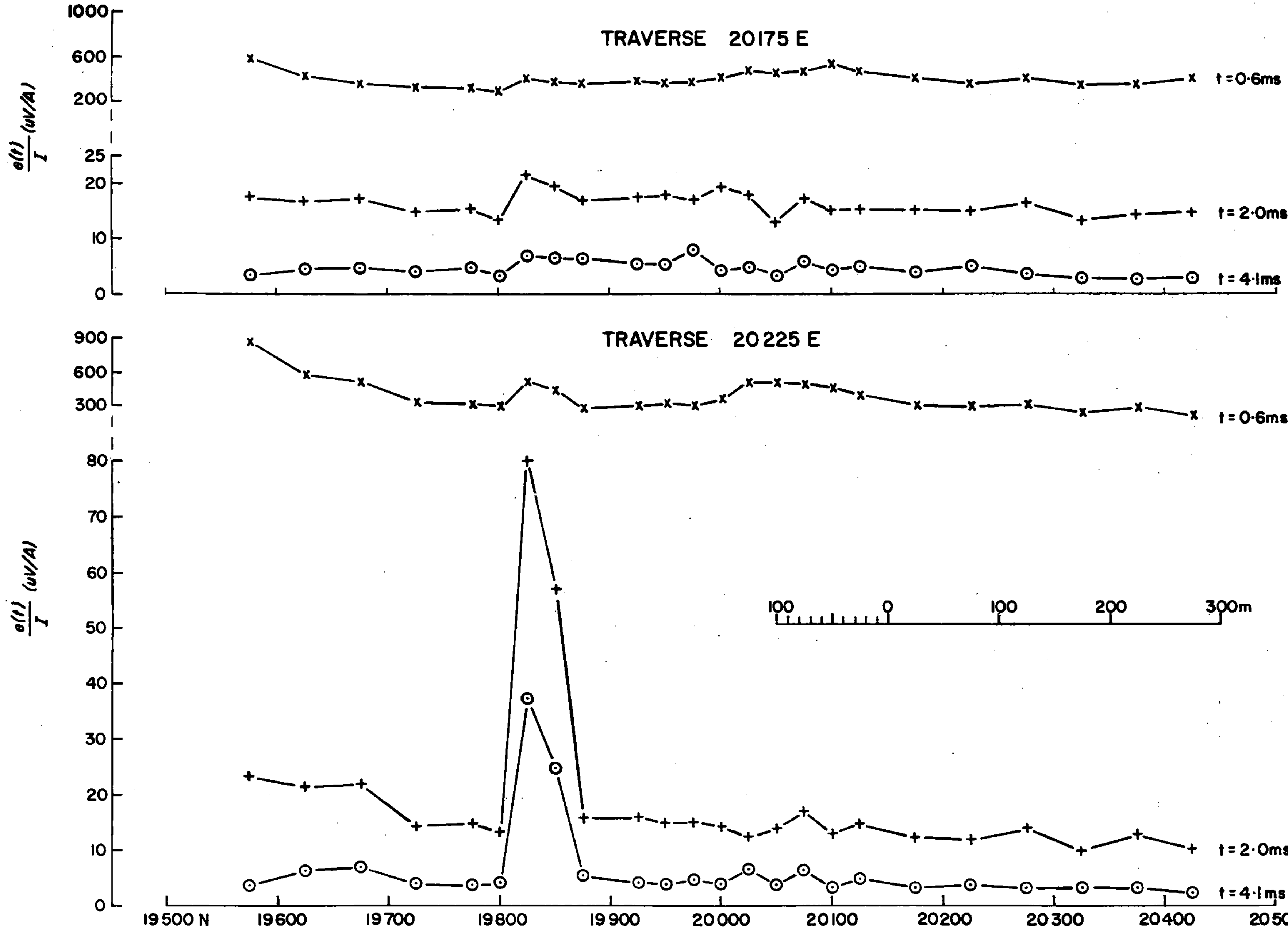
Fig. 4



TEM PROFILES, TRAVERSE 20250 E (100-m loops)

Fig. 5



TEM PROFILES, TRAVERSES 20175 E, 20225 E

(50-m loops)

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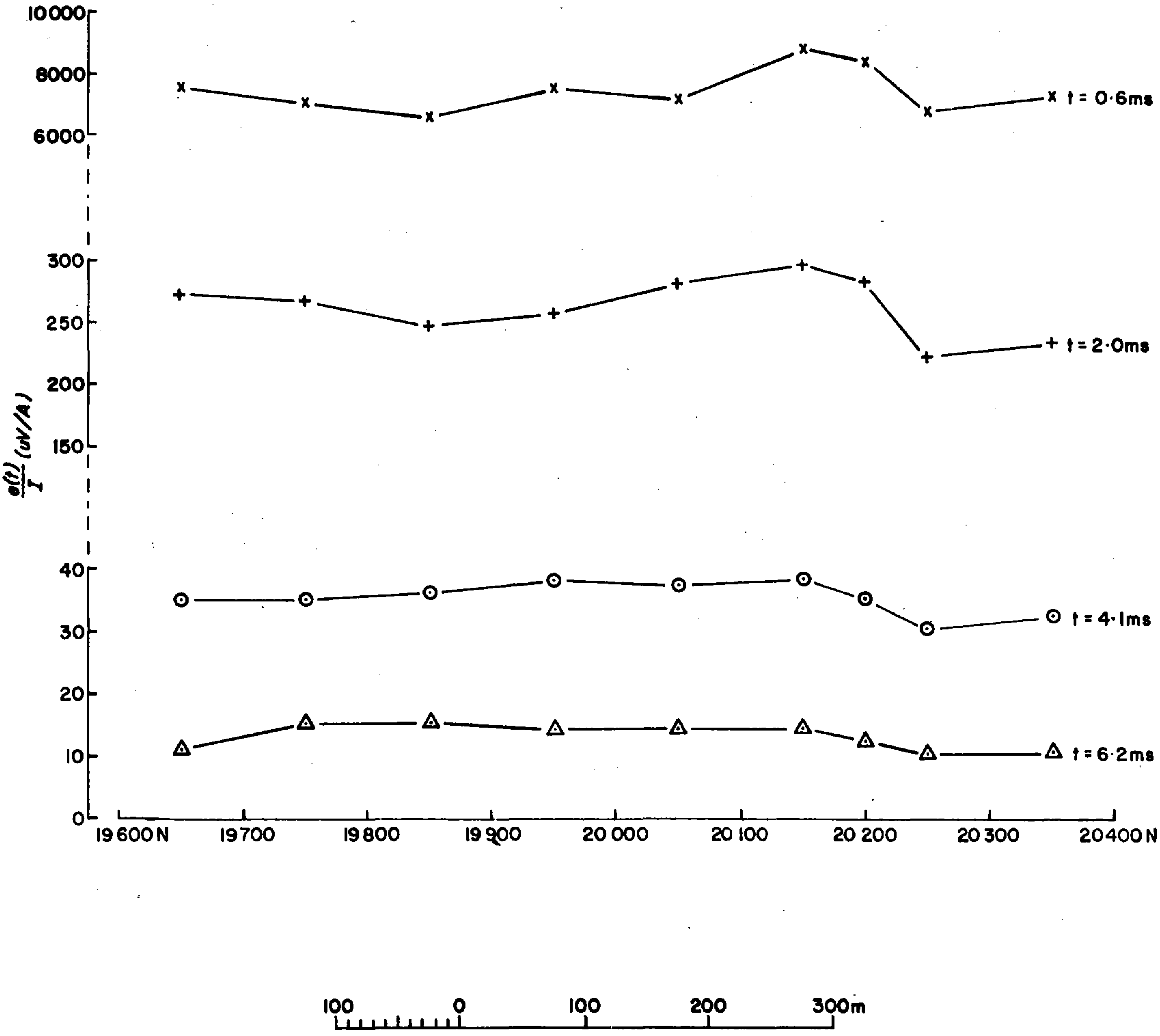
Fig. 6

Fig. 7



TEM PROFILES, TRAVERSE 19750 E

(100-m loops)

Note that no anomalies were recorded on this traverse, and that background response levels are generally larger than those recorded on traverses 20150mE and 20250mE which also employed 100-m loops.

7. DISCUSSION

TEM response at Elura

The results of the Elura TEM survey clearly show the screening effects of a conductive overburden as both background (screening) responses and discrete anomalies are observed. The background responses occur on all traverses as a high and uniform signal level which decays fairly rapidly with time. The background response is assumed to be due to the presence of a thick conductive surface layer. Discrete anomalies are superimposed on this background response at later delay times when the background response has decayed sufficiently to allow observation of the less rapidly decaying response from bodies with a high conductance.

Analyses of background response

The apparent conductivity of the survey area has been determined using a method described in Hone & Spies (1974, Appendix 1), which compares the signal levels with the response from a homogeneous half-space as determined by Lee & Lewis (1974).

Using the background responses for the different loop sizes and traverses calculations indicate that the surface layer has a conductivity of about 0.1 Siemens per metre which is in good agreement with the apparent resistivities reported by Ogilvy (1976). The surface conductivity along traverse 19750mE would appear to be somewhat higher than that along traverses near 20000mE.

The similar apparent conductivities calculated for various loop sizes, and therefore depths of penetration, indicate that the conducting surface layer is quite thick and uniform. This deduction is supported by Ogilvy's (1976) work, which indicates a conductive blanket up to 90 m thick.

Analyses of the TEM anomalies

The geoelectric environment described above is not well suited

suited to electromagnetic prospecting with conventional techniques such as Turam and Slingram.

However, with the TEM method, definite anomalies were recorded at late delay times using 200-m and 100-m loops near the known massive mineralization. The locations of these TEM anomalies - and of the chargeability anomalies described by Ogilvy (1976) - are shown in relation to the horizontal axis of the sulphide body in Figure 8. The TEM anomaly recorded over the mineralization on traverse 20150mE appears to have a fairly deep and conductive source which may be the massive sulphide body. However, in general, the TEM anomalies are associated with a zone of high chargeability which is northeast of and not parallel to the zone of massive mineralization.

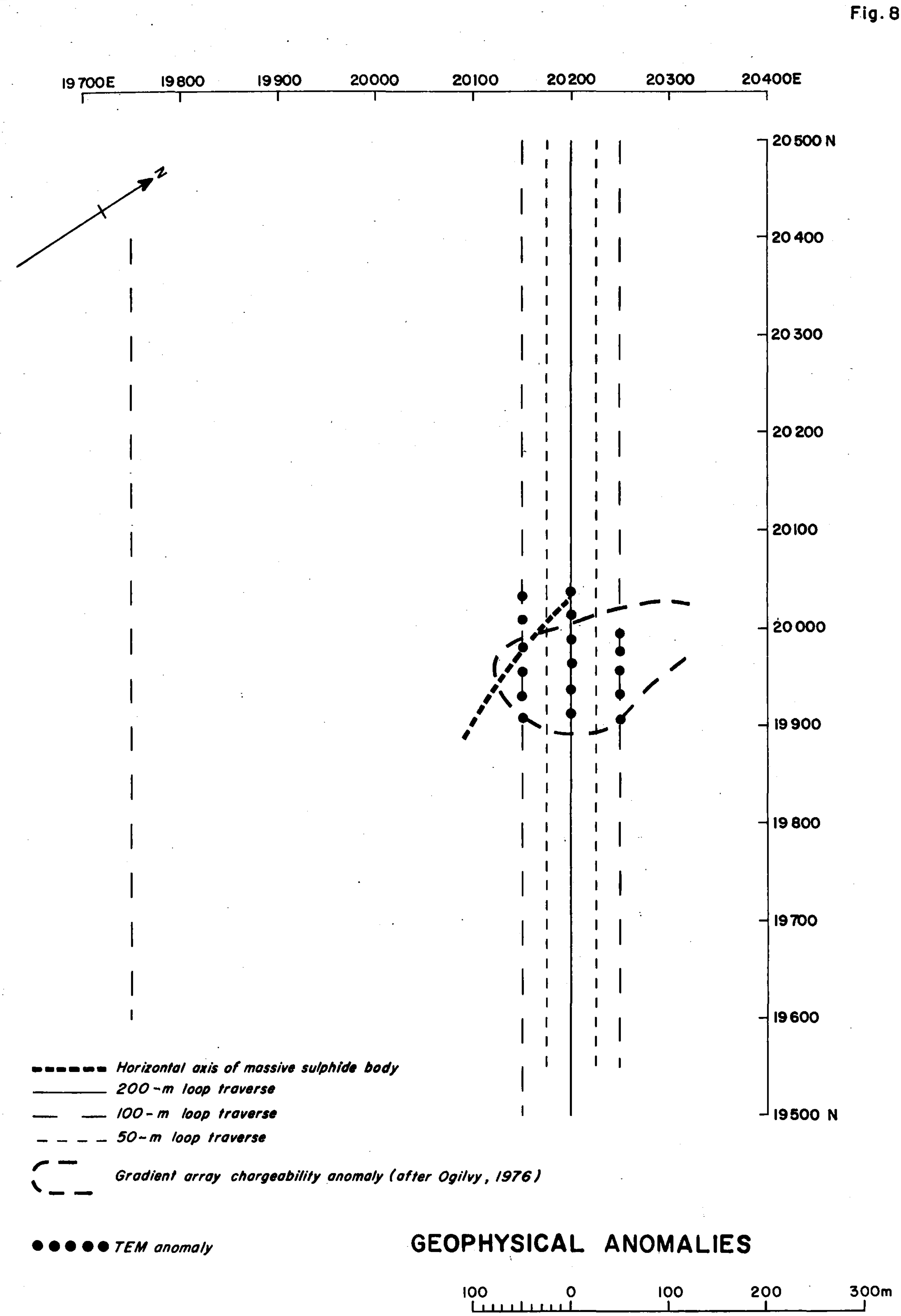
Although noise at late delay times prevents accurate determination of time constants for the decay of the responses, the anomalies appear to have a time constant of about 7 ms, and the background a time constant of about 5 ms. A time constant of 7 ms indicates a source with a fairly high conductance.

The depth to the source of the TEM anomalies is not easily determined. Simple modelling using a spherical conductor and Velikin & Bulgakov's (1967) empirical method suggests a maximum source depth of 100 m for the 200-m loop response. A comparison of the 100-m loop results indicates that the source may shallow to the east, and the absence of anomalies on the 50-m loop traverses shows that the source does not come to the surface in the survey area.

Source of the TEM anomalies

Analyses of the TEM anomalies near the known zone of massive mineralization indicate that they reflect a conductor with a fairly high conductance above and to the east of the known zone of massive mineralization.

It is suggested that the source of the TEM anomalies is related to the massive mineralization at depth, and may be a conductive zone of sulphide stringers or weathered mineralization above the massive mineralization.



GEOPHYSICAL ANOMALIES

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8. CONCLUSIONS

Owing to the low signal-to-noise ratio at late delay times, and the effects of a conductive overburden, the TEM results from the Elura survey were difficult to record and interpret. However, a discrete conductor which is probably related to a body of massive sulphides was detected, and its response could be separated from that of the conductive overburden.

The results indicate the potential of the TEM method to search for massive sulphides in and through a conductive overburden such as the one in the Cobar area. The exploration capabilities of the TEM method in this environment could be enhanced by improving the signal-to-noise ratio of the measurements, and by extending the delay time capability to 50 ms.

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