INTERPRETATION AND DESIGN OF TIME DOMAIN ELECTROMAGNETIC SURVEYS IN AREAS OF CONDUCTIVE ORVERBURDEN

B.R. Spies

Bureau of Mineral Resources (062 – 49 9111)

The TEM method is being used increasingly for mineral exploration and geological mapping in Australia. The techniques can be divided into one-loop and coincident-loop systems (MPPO–1, MPP–3, SIROTEM) and two-loop systems (Pulse EM, Newmont EMP, SIROTEM, UTEM); the two systems exhibit markedly different responses over the conductive surface layers which cover much of Australia. Exploration in the eighties by this method will depend on developing methods of quantitative interpretation of anomalies caused by variations in the surface layer.

The response of both one-loop and two-loop systems to variations in the conductivity and thickness of a conductive surface layer or host rock has been investigated. The response of a homogeneous ground is relatively simple for a one-loop configuration, but becomes much more complex as the transmitting and receiving loops are separated, forming a two-loop configuration. For a two-loop configuration the response changes sign at a time which depends on the loop separation, L, and ground conductivity, σ. This process can be visualised using the equivalent current filament, or "smoke-ring" concept of Nabighian (1978). After the current in the transmitter is switched off, the maximum in the electric field moves downwards and outwards, keeping the same shape as the transmitter loop. The sign reversal measured at a time given by $t = 0.16\,\sigma\mu L^2$, when the magnetic field from the equivalent current filament is horizontal at the ground surface. In resistive terrains the sign reversal is usually not observed, but in areas with conductive surface layers the sign reversal can occur at quite late times. Variations in the conductivity of the overburden can cause complex anomaly shapes which are difficult to interpret intuitively and to distinguish from anomalies caused by con-

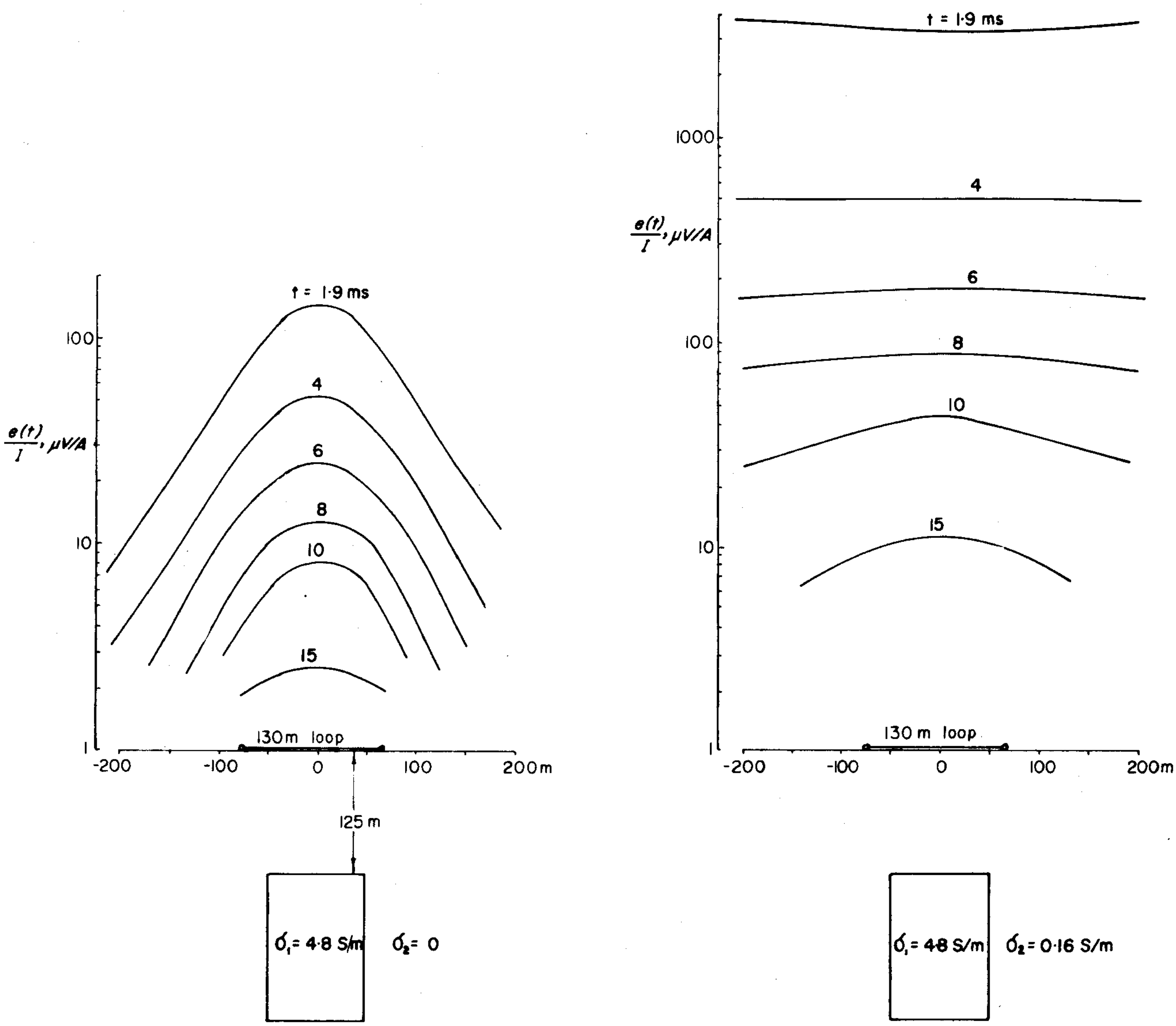

FIGURE 2

Coincident loop TEM results for Elura model, with and without a conducting host rock.

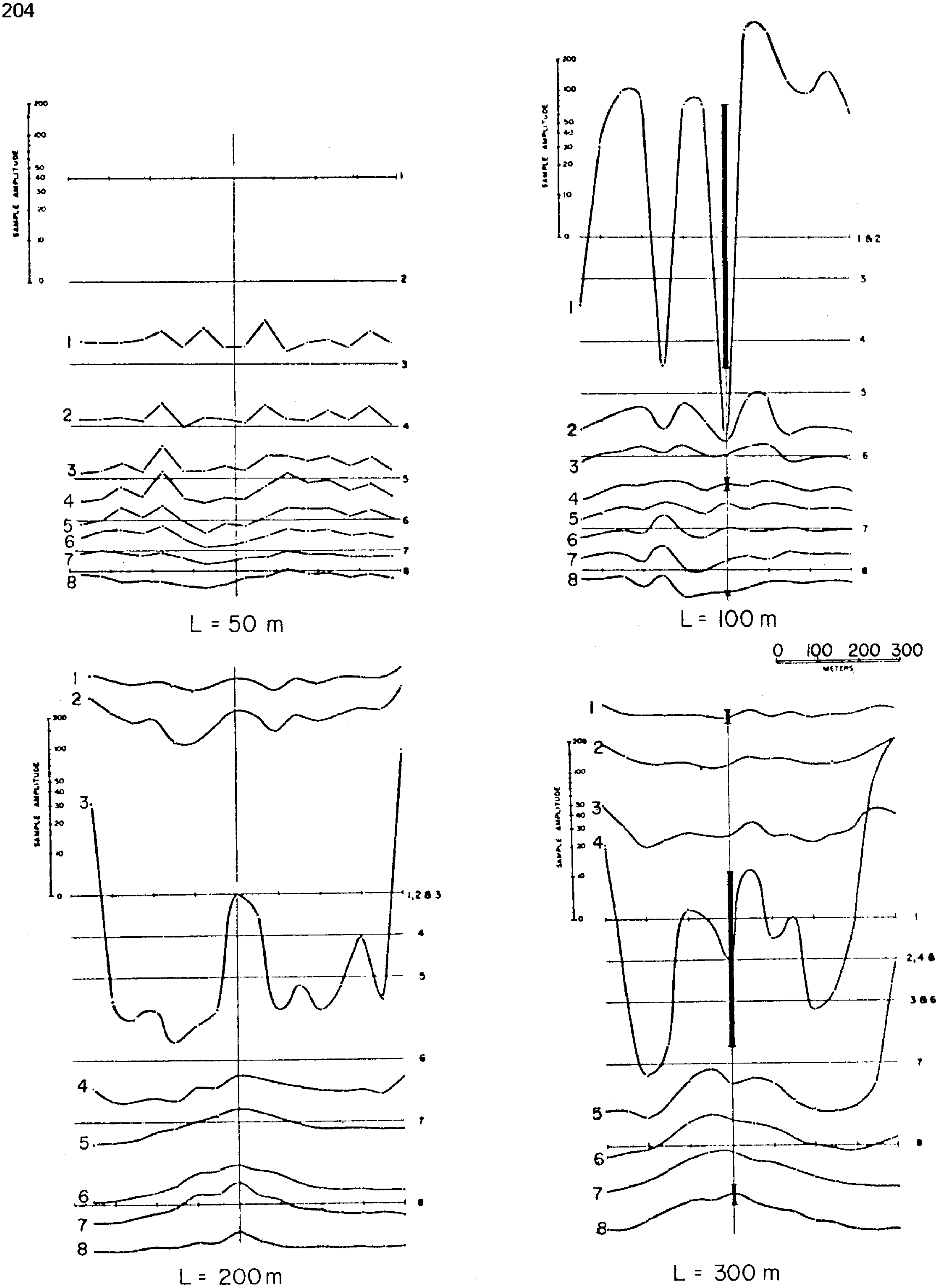

FIGURE 1

Pulse EM profiles for various loop separations, Cobar, N.S.W. The vertical bars indicate the change resulting from a variation of 10% in the conductivity of the overburden.

ductive, bedrock sources. This problem holds for both one-loop and two-loop configurations, but is further complicated by the sign changes in a two-loop configuration.

Such two-loop sign changes are evident in the Pulse-EM data from Cobar shown in Figure 1, for loop separations, L, of 50, 100, 200 and 300 m (Crone, 1978). For L = 50 m, the profiles at all sample times are negative. As the loop separation is increased, the response at early times changes to positive values. Variations in the conductivity of the overburden can cause large changes in response for sample times about that of the sign change. The vertical bars in Figure 1 for L = 100 and 300 m are the changes in response which would be caused by a variation of 10 percent in the overburden conductivity. For a one-loop configuration the change in response with variations in conductivity exhibits a gradual variation with sample time.

Interpretation of two-loop data is further complicated because the response of a finite conductor in a resistive host-rock also exhibits sign changes, which depend on depth of burial or conductivity. Thus for ease of interpretation, a one-loop configuration is recommended; this can be approximated in a two-loop system by locating the receiver in the cnetre of the transmitter loop (sometimes called "in-loop" or "frame-loop" configuration).

The concept of limits of detection has been investigated by studying the modelled response of the Elura and Roxby Downs deposits using an interactive mini-computer analogue model system (Spies, unpublished data). The TEM response is determined for a variety of loop sizes, depths of burial, and conductivities of the deposits and host rocks. An example of this study is shown in Figure 2, for a model of Elura (conductivity = 4.8 S/m) at a depth of 125 m, with and without a conductive host with conductivity 0.16 S/m. At early times the response of the body is screened by the host or overburden. The body is not detected until about 6 ms, which corresponds to $t = 10^{-6}\,\sigma h^2$, where h is the depth of the body. At late times the response of both one-loop and two-loop systems was found to be fairly similar.

The Roxby Downs study consisted of modelling tabular bodies with a range of sizes, at a depth of 350 m. The limits of detection of this type of target depend mostly on its size and the conductivity contrast between the deposit and host rock. A model 1500 m long, 300 m wide and 150 m thick can be detected with a conductivity contrast as low as 50:1, but a smaller model, 900 m by 180 m by 90 m requires a conductivity contrast of 100:1. For optimum detectability, the loop size should be of the same order as the target.

For both the Elura and Roxby Downs model studies, it was found that the optimum time range for measurement was between 1 and 50 ms. Measurements at earlier and later times, however, give useful information on conductive host rock or overburden.

References

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THE APPLICATION OF SIROTEM IN WEATHERED TERRAIN

G. Buselli

CSIRO Division of Mineral Physics (02 – 888 1666)

I. Introduction

SIROTEM is an instrument developed for multichannel TEM measurements. Details of characteristics of this instrument are described by Buselli and O'Neill (1977). Over the past two years SIROTEM has been applied widely in many different terrain types. In particular, considerable success has been achieved in detecting mineral deposits occurring under conductive overburden of thickness up to 100 metres.

Data collected with SIROTEM along a given traverse line can be represented in the form of a profile of the response for each channel. To interpret these profiles in terms of target geometry, conductivity and host rock properties, a system has been set up at CSIRO to model responses from thin dipping dykes, using a SIROTEM unit to collect the modelling data. The dykes are modelled both in air and in conductive media, using both separated and coincident loops configurations.

The apparent resistivity output of SIROTEM provides a means for producing in-field pseudo-sections of apparent resistivity. The apparent resistivity for each channel is plotted vertically as a funciton of station position, which is plotted horizontally.

II. Geological Data

The following gives a brief outline of the geological environment for each of the case studies to be presented in this paper.

Case Study No 1: The Elura deposit near Cobar NSW

Massive sulphide mineralisation occurs at a depth of approximately 100 m below conductive overburden with a resistivity of the order of 15 Ωm. The deposit is a near-vertical pipe-like structure, oval in horizontal section with maximum dimensions of the order of 200 m by 100 m in horizontal section at a depth of 200 m.

Case Study No 2

A thin steeply dipping conductor lies below conductive overburden of thickness 70 m and resistivity approximately 10 Ωm.

Case Study No 3

This massive sulphide deposit is a thin lens dipping at approximately 50°. It occurs in association with conductive sediments in the hanging wall. The electromagnetic response of these sediments could interfere with that of the target. The deposit occurs under conductive overburden of resistivity less than 10 Ωm, and the depth to the top of the lens is ~100 m.